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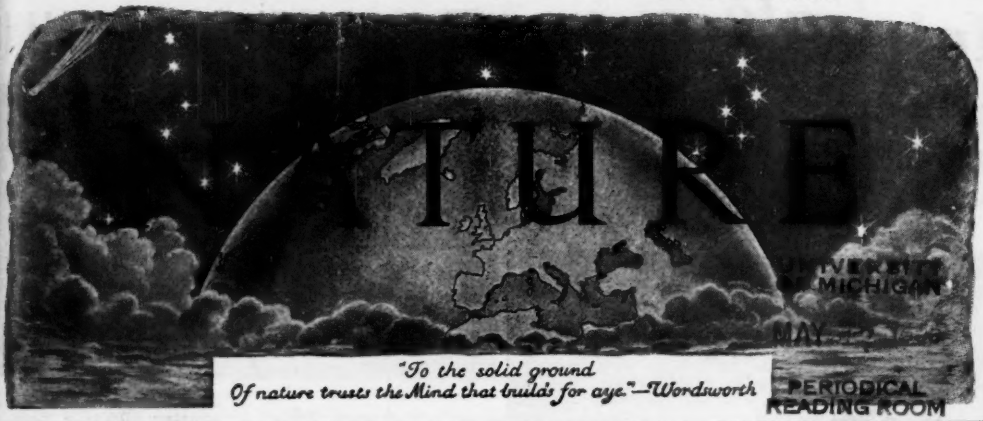

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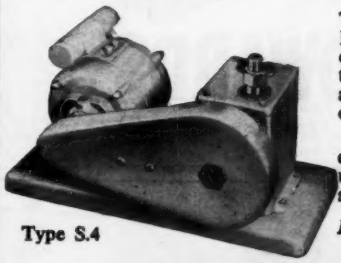

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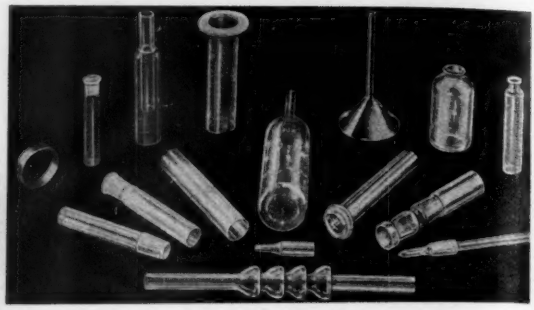

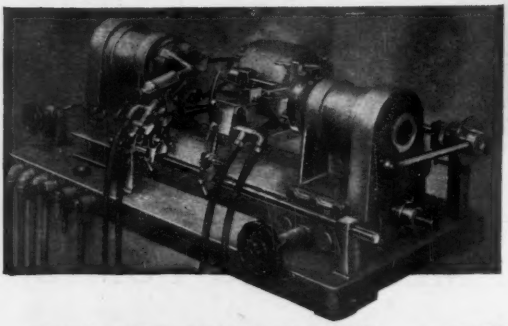

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MAN-POWER AND RESOURCES IN DEFENCE POLICY

THERE was little evidence in the debates in Parliament on March 1 and 2 that the critical importance of science in defence is clearly appreciated by politicians. The references by Mr. Martin Lindsay and Lord Templewood and Lord De L'Isle and Dudley to the chronic shortage of skilled men, technicians, technologists and scientists in the radio-engineering and aircraft industries were perhaps the clearest indication in the debate that defence policy is ultimately conditioned by our resources of trained man-power and the disposition of those resources to the best advantage. On that the recent Statement on Defence* gives little guidance. It refers to the problems which the threat of nuclear attack presents to the air defence forces of Britain, to the further increase in the proportion of all-weather radar-equipped fighters and the high priority which continues to be given to the development of guided missiles, to the increased need for flexibility imposed on land forces so as to be able to move from dispersion to concentration as quickly, and with as little confusion, as possible, and to the greater elasticity of outlook required by commands at all levels and the modification in organization and equipment of fighting units. It is taken for granted, however, that all this and the transformation and re-equipment of the Navy with nuclear and with guided weapons are tasks well within the scientific and technical resources of Britain without over-straining the economy of the country.

"Within the limits of our resources . . . we are planning for a better-equipped and maintained Active Fleet and a reduced but much more highly prepared Reserve Fleet; a smaller, better disposed, more mobile Army; and a more powerful Air Force including, in particular, an effective strategic bomber force." All these forces are to be armed with the most modern weapons, and while there is reason for believing that thermonuclear weapons need not prove quite so costly as the original prototypes, there is no indication in the White Paper of technical factors which would permit the cost of defence to be pruned. In fact, on the man-power situation it is disquieting, and the section on research and development is far from providing an adequate basis for informed discussion.

In regard to man-power, it is apparent that the Services are already finding it difficult to recruit adequate numbers of long-service men of the standard required; and the defence debates, notably that in the House of Lords, showed that this is a question which touches very closely the supply of scientists and technicians in general. As Lord Templewood pointed out, the Services have a continuing problem of recruiting the scientists and technicians they need in competition with industry. This cannot be dismissed as a temporary problem, and long-term solutions are no more likely to arise out of palliatives than the shortage of science teachers in schools—with which it is related—will be removed by piecemeal and patch-work measures.

The need for overall consideration of the demands made on the scientific resources of Britain, and especially in man-power, applies even more clearly in the section of the White Paper which discusses research and development. These are notably affected by the decision to base defence policy primarily on the maintenance of the nuclear deterrent to aggression. The research and development programme as a whole has recently been fully reviewed in the light of this decision; but it is still necessary for Britain to continue with the development of other weapons. Many of the projects on which Britain is expending much effort are as yet unproved, and with so much at stake it would be wrong prematurely to abandon all other lines of development. Moreover it is still true (and of other countries as well as of the United Kingdom) that the time taken to put the new types of weapons through all the various stages of research and development into production tends to be very much longer than in the past.

The British organization for defence research and development has been stated authoritatively to compare well with that of the United States, for example, but that is no reason for complacency. The range of effort barely recapitulated in the White Paper might well prompt the disquiet evinced in the defence debates, notably in that on the Air Estimates in the House of Commons, when Mr. C. I. Orr-Ewing and Mr. Paul Williams suggested that the present and increasing shortage of skilled technicians in industry, for research and as science teachers in the schools is the Achilles heel of the defence programme and of economic development in the United Kingdom and the Commonwealth. The White Paper gives no indication of the demand for man-power which the programme of research and development involves; nor is the exact expenditure for that purpose to be discovered. Lord Alexander of Hillsborough suggested it might be of the order of £160–180 million, and asked how the actual research cost is allocated and its distribution between the Services concerned.

Little information was forthcoming in the debates to remove the misgivings evinced both in the House of Lords and the House of Commons; what is clearly required is an indication that the research effort is being planned with due regard to the country's scientific and technical resources. Neither the debates nor the White Paper dispelled the concern that Britain may be attempting too much with limited resources, and that our contribution to Western defence as well as to that of the United Kingdom and the Commonwealth might be more effective if we concentrated our effort on carefully chosen, but

* Statement on Defence, 1955. Pp. 30. (Cmd. 9391.) (London: H.M. Stationery Office, 1955.) 1s. net.

more limited, objectives. The White Paper, for example, refers to the close collaboration which exists with the United States in the field of guided weapons. Comprehensive arrangements have been made for the exchange of information and of visits by technical personnel. Nevertheless, Parliament was far from being satisfied that everything possible is being done to eliminate duplication of effort and to exchange information. In the debate on the Navy Estimates, for example, reference was made to the importance of exchanging information on research on hydrofoil boats not only with the United States but also with Europe.

This point has been pressed repeatedly in the House of Commons recently, particularly in respect of the exchange of information on thermonuclear weapons and on the effect of radiation resulting from the explosion of nuclear weapons. Mr. H. A. Nutting stated on March 14 that we are at present in touch with the United States Government as to the possibility of concluding a bilateral agreement on the exchange of information generally under the United States Atomic Energy Act, 1954; but Mr. J. Grimond was right to emphasize the present concern in Britain as to the lack of co-operation over thermonuclear and other forms of weapons in the armament programme. None of this is covered by the United States Atomic Energy Act of 1954: the McMahon Act still restrains the exchange of information on the theory, design and manufacture of nuclear weapons. The interest taken in Sir William Penney's recent visit arises largely from the hope that it may lead to some initiative in this direction from the United States side, or at least lead the United States to doubt the wisdom of restrictions which encourage waste where co-operation could be most fruitful to both sides.

Britain must, of course, have something to offer; but no doubts need be entertained on that score so long as the country's efforts are not dispersed too widely. These problems, however, scarcely received the attention they demand in the defence debates, and with the general acceptance of the main basis of the Government's defence policy, it is essential that its technical, as well as its political, implications should be clearly understood and constructively criticized. This is the more important in that the Government made no attempt in the defence debates to meet a number of points raised, and also in view of the evidence in the Statement on Defence and in the replies to questions as to the radiation effects of nuclear explosions that the Government is scarcely giving sufficient attention to the matter of co-operation. The Statement has indeed a section on "Co-operation within the Commonwealth and with International Organisations", but no reference is made in it to the importance of preventing duplication of research, and the cost of security is sometimes confused with that of independence.

That is true of other countries as well as Great Britain and the United States; but even Anglo-American co-operation is not facilitated by political party bickerings, or the disposition to make party capital out of what are essentially technical issues. In pressing for the maximum possible co-operation in defence research and development, it should be remembered that evidence of united purpose and continuity of policy are powerful factors in attracting the response that co-operation implies. It is quite clear that those who, like Lord Winster, asked in the debate whether we could undertake the manufacture of thermonuclear weapons without dropping something else, did so in no party spirit; and the question, like those regarding scientific and technical man-power, deserved a fuller answer than it received from Government spokesmen in either House.

Next to the over-riding importance of full co-operation with our partners in Western defence, especially in thermonuclear weapons, the White Paper and the debates on defence demonstrate the critical importance of scientific and technical man-power. Short-term expedients to meet particular sudden emergencies are no substitute for a considered policy which will ensure that a steady and continuous supply of men and women of the requisite calibre is available where they are needed. To achieve this without untoward effects on other sectors of the national economy and without disturbing the flow of new knowledge upon which defence, no less than industrial advance, depends, demands foresight and imaginative planning, as well as a large measure of co-operation from the universities and educational authorities, government departments and industry as well as public corporations and research institutions. It is a matter of the wise use of scientific and technical man-power as well as of training and distribution, and only a considered policy will avoid recourse to methods of distribution which could well do more harm than good.

Such a policy can only be expected when the Government shows a real appreciation of the importance of science and technology and their bearing on defence, industrial development and public welfare in general, and is prepared to shape policy accordingly and to provide the organization and means by which science and technology can be most effectively applied to the national purpose. Once again the Government singularly failed to provide in the defence debates any evidence that it understands the importance of science and technology even in defence, or that the success of the policy laid down in the White Paper ultimately depends on whether Britain possesses resources in scientific and technical man-power to implement the programme outlined. On this vital question, both the Lord President of the Council, generally regarded as the responsible head of the national effort in scientific research, and the Minister of Defence, were silent. Clearly the time is ripe for reconsideration of the whole organization by which the nation's limited resources in science and technology, both in men and materials, are brought to bear most fruitfully and effectively on the objectives which defence policy and national welfare demand. Constructive thinking here would facilitate sound answers to the many important questions which Government spokesmen have so far parried.

CURRENT PROGRESS IN PSYCHICAL RESEARCH

Modern Experiments in Telepathy

By Dr. S. G. Soal and F. Bateman. Pp. xv+425+3 plates. (London: Faber and Faber, Ltd., 1954.) 30*s*. net.

A New Approach to Psychical Research

By Antony Flew. Pp. viii+161. (London: C. A. Watts and Co., Ltd., 1953.) 10*s*. 6*d*. net.

Psychical Research Today

By D. J. West. Pp. 144+8 plates. (London: Gerald Duckworth and Co., Ltd., 1954.) 12*s*. 6*d*. net.

THESE three books on modern progress in psychical research are a fair indication of what students are doing and thinking in this hotly debated field. In the first of them, by Dr. S. G. Soal and Mr. F. Bateman, the authors have given us by far the most important work on extra-sensory perception that has hitherto appeared. Not only do they present an admirably documented and critical survey of most of the experimental work in the past; but here also will be found in convenient form a full and detailed account of the famous series of card-guessing tests with the two most outstanding British subjects, Mr. Basil Shackleton and Mrs. Gloria Stewart. On reading these records, it is clear that, by their insistence on the most rigid experimental technique, the authors have shown that work in this field can be carried out and brought to fruition as in other branches of science.

Owing to the apparent scarcity of good subjects, much laborious work has to be undertaken with results that, in the end, are wholly without significance. The same precautions, however, have to be observed in every case and the same careful scrutiny of the completed scores. It was only after ten years of such trials that Dr. Soal was fortunate enough to meet his two subjects who, after repeated tests, showed a consistently high rate of scoring which continued after, it would seem, every conceivable precaution had been taken. It is this consistency, coupled with the results of sudden changes in the technique, that makes the theory that extra-sensory perception is something of the nature of a statistical artefact very difficult to sustain.

In the early chapters a short survey of the work from 1883 is attempted; but chief attention is rightly given to those series where statistical evaluation of the results was achieved. They show how various sources of error were detected, met and eventually eliminated; how attempts were made to correlate extra-sensory perception with personality ratings, and how Carington's claims for the validity of his results in matching drawings cannot be justified unless an intensive inquiry into common preferences of varied cross-sections of the population has been carried out.

In the present volume, the authors have made but little attempt to discuss their results from the point of view of the psychologist or the philosopher. Such was not their intention. Their aim was to describe and evaluate experimental work, and not to deal with any implications in relation to other fields of inquiry. It is here that Prof. Antony Flew's little book on the connexion between psychical research and philosophy fills the gap. After a brief account of the subject-matter of his thesis, he goes on to discuss the meaning of many of the phenomena reported, and stresses the difficulty of dealing with a subject where so much out-moded terminology abounds. He believes an approach must be made towards revising these linguistic pitfalls, and that some new terminology should be adopted which is theoretically neutral and not liable to cause so many logical and philosophical perplexities. Believing as he does that extra-sensory perception is a fact, Prof. Flew is at pains to point out that our knowledge of it is so meagre that great care should be exercised lest, by faulty linguistic description, false ideas may be engendered. He maintains, indeed, that almost all the terms in current use are radically unsatisfactory; and in pointing the way to a new nomenclature he directs the attention of psychologists and philosophers to those phenomena which are more and more engaging the serious consideration of experimenters in this field. How varied are these phenomena and with what caution they have to be treated is set out in concise fashion in Dr. D. J. West's account of psychical research as seen to-day.

It is clear that, in this well-documented and objective survey of the present situation, the author is well acquainted with modern tendencies and the strength and weakness of many of the cases he discusses. Generally speaking, he is inclined to be cautious, and it may come as a surprise to some to find that he regards the evidence for the spontaneous cases such as apparitions as well as various types of veridical hallucinations as far less cogent than has hitherto been supposed.

In his treatment of mental mediumship, the physical phenomena, hauntings and poltergeists, Dr. West is restrained and critical; and it is only when he treats of progress in work on extra-sensory perception that he shows much enthusiasm. For it is his opinion that, apart from extra-sensory perception and possibly some form of precognition, all is controversy and speculation. In recognizing that extra-sensory perception itself cannot be explained upon any physical basis, he joins hands with Prof. Flew in laying stress on the harm that a faulty nomenclature may have on our ideas. As Dr. West concludes, the subject is one big question mark; but he hastens to add that it is remarkable that research has gone so far as it has. For those who wish to become better acquainted with that research, to learn how it is conducted and what may be some of its implications, then these three books are to be recommended. They are some of the most important contributions to the subject that have appeared within the past five years.

E. J. DINGWALL

MOLECULAR STRUCTURE

An Advanced Treatise on Physical Chemistry

By Prof. J. R. Partington. Vol. 5: Molecular Spectra and Structure, Dielectrics and Dipole Moments. Pp. x+565. (London: Longmans, Green and Co., Ltd., 1954.) 80*s*. net.

THE latest instalment of Prof. J. R. Partington's prodigious treatise fills the reader with no less astonishment than did its four predecessors. Anyone who reflects on the enormous effort needed to write what are effectively the two text-books which comprise this particular volume will want to congratulate the author. His lucidity, his breath-taking comprehensiveness and his historical sense, already commented on in reviews of the earlier volumes, are

no less evident in this. Chemists in general will be interested to learn that there are more than four thousand distinct literature references, many of them going back up to a hundred years; and, of these, nearly one-third are to American workers, and one-quarter each to British and German.

In a treatise of this kind, some sort of selection has to be made from all the material available; and in such a selection everyone will be disappointed somewhere or other. In the section on molecules the account of molecular structure is quite good, though it does not do sufficient justice to the concept of hybridization; but the account of molecular spectra is, by contrast, very thin, ionization potentials being scarcely mentioned and Rydberg series entirely omitted. In the same way there will be many who will regret that nothing is said about the concept of co-operative phenomena in the chapter on dielectrics.

Prof. Partington is most anxious that no one should fail to understand his analysis through insufficient knowledge of mathematics. So everything which is needed is fully developed. The result is uneven: there is the proof of the relation between the three moments of inertia for a plane lamina ($I_x + I_y = I_z$); and there are also sixty solid pages of formulæ and analysis connected with spherical harmonics. Perhaps some of this latter may be used in later volumes: certainly not much of it was needed in this, and much of it is considerably more advanced than is the formula for moments of inertia.

When I had finished reading this book, I could not help wondering whether a task of this immensity is really possible for one person. For the subject-matter is too diverse for any person, however learned, however versatile, however patient—and Prof. Partington has all three of these qualities. It is inevitable that there should be mistakes. I found seven or eight quite serious ones, varying from the assertion that the spins of the two 3*s* electrons in magnesium could be either parallel or anti-parallel, to the remark that under certain conditions the molecule H_2 could be raised to a higher rotational level of 3·54 eV. Quite apart from the lack of balance that was referred to earlier, these mistakes do detract from the reliability and trustworthiness of the book. I should not wish to let it fall into the hands of an unsuspecting undergraduate. But research students and intelligent undergraduates who have been forewarned will find it a mine of information, and will rejoice at the simple unaffected style and the sound historical feeling which are so evident within its pages.

C. A. Coulson

CHEMICAL LECTURE EXPERIMENTS BY SCREEN PROJECTION

The Screen Projection of Chemical Experiments
By Prof. E. J. Hartung. Pp. xiv+291. (Melbourne: At the University Press; London: Cambridge University Press, 1953.) 30*s*. net.

THE literature of chemical lecture experiments is not extensive, and the addition to it of a book on a novel and special branch is welcome. Modern projection apparatus and technique permit small-scale experiments to be made easily visible to a class. A number of schools in Great Britain have for years used such aids, and descriptions of home-made microprojectors and other apparatus, and here and there suitable experiments, have appeared in journals devoted to science teaching. Prof. E. J. Hartung, professor of chemistry in the University of Melbourne, has now prepared a thorough and systematic account of the requisite apparatus, techniques and experiments.

He devotes his first six chapters as follows: general principles of projection optics; description of equipment, including, among other items, light sources, cooling devices, lenses, mirrors, prisms, screens, projection microscopes, polarizing apparatus, diascopes and universal projectors; arrangement of the lecture room; and general notes on the actual technique of demonstration. The headings of his last eleven chapters are also those of the classes into which for convenience of treatment he has divided the two hundred and fifty experiments he describes. He gives full directions for carrying out each of these experiments and suggests the most suitable type of projection.

Experiments, notably those illustrating the Brownian movement, anisotropy and enantiotropy, lend themselves admirably to screen projection and, with economy of time, cannot be effectively shown to a large class in any other way. Prof. Hartung's selection includes many of the above class and, among other exceedingly good ones, some leading to an understanding of selective adsorption and illustrating differential flotation.

Mingled with these excellent illustrations are numerous simple reactions illustrative of elementary chemistry, such as the acidity of soda water, the interaction of carbon dioxide and lime water, the displacement of lead by zinc, the action of ammonia on copper salts, and so on, reactions which students can readily carry out by themselves, and which few teachers would call lecture experiments. I admit that by screen projection are revealed some phenomena, such as the streaming of invisible gases, which are not seen in the ordinary way of experimenting; nevertheless, I consider that the author has done his book a disservice by including so many experiments of the above class, for he thus makes his instruction entirely informative and gives no scope for the investigative spirit. Be that as it may, the teacher himself from the abundance herein given can select which experiments to screen, and all who desire to support their discourses with striking and beautiful illustrations should make themselves acquainted with this book.

G. Fowles

OIL IN THE U.S.S.R.

Oil in the Soviet Union
History—Geography—Problems. By Dr. Heinrich Hassmann. (Translated from the German with the addition of much new information by Alfred M. Leeston.) Pp. xvi+173. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1953.) 3.75 dollars; 30*s*. net.

THE Russian way of life and the philosophy of Bolshevism may be enigmatical to Western peoples, but at least her economic and political activities in their external impacts may be scrutinized objectively; in particular, her oil industry can be described and assessed at its present level. To comprehend past developments of the Russian petroleum industry and

present trends, and to anticipate future hopes and achievements, demand at the outset a clear picture of the enormous territory involved in the Soviet Union, approximately nine million square miles or three times the size of the United States. With this are involved considerations of history, population, constitution and economics, each of which is convincingly portrayed by Dr. H. Hassmann in this book as the background to the main theme. The existing political setting necessarily features in the book, especially as it affects the economic system; but commendable effort has been made to avoid military or ideological implications, and also indulgence in what might be called 'wishful oil thinking'.

To students of oil technology, "Eternal Fire of Surakhany" ranks with many other actual and mythical indications of petroleum chronicled by the ancients, as a chapter in the genesis of the industry itself. Baku has remained classic not only throughout Czarist times but also under the existing Soviet regime. Fields such as Baku, Groznyy, Maykop, Emba, Cheleken, Sabunchi, Balakhany, Romany and Bibi-Eybat individually achieved through the years international fame, both for geological and production reasons; early in this century the Binagady and Surakhany oilfields added their quota to this highly concentrated, unique Apsheron Peninsula; now, as then, this Peninsula is of prime importance in Russian oil developments.

In the present scheme of things, the State is both owner and operator of the industry. From initial geological and geophysical surveys, through the long sequence of drilling, production, refining, transport and distribution of petroleum and its products, the State is the authority. In it is further vested supply and control of man-power, working conditions and all finances, the latter embracing not only costs of production but also prices of finished products. The oil industry in this perspective is thus seen as an integral part, a vitally important one, of the whole economic system of the U.S.S.R. In actual practice, oilfields and oil plants are merged as individual 'trusts'; these in turn are combined into larger groups, the latter under direct control of the Federal Ministry of Petroleum Production with a Minister at its head. Thus Soviet oil to-day revolves around eight indigenous groups: Azneft (Baku); Grozneft (North Caucasus); Krasnodarneft (Northwest Caucasus); Kuybyshevneft (Ural-Volga); Molotovneft (Ural-Volga); Bashneft (Ural-Volga); Kazakhstanneft (Emba); and Sredasneft (Central Asia). In addition, there are several trusts under the direct control of the Ministry—for example, Dagneft in Dagestan, and Sakhalinneft on Sakhalin Island.

In so far as statistics provide supporting evidence of modern developments of Russian oil, important facts to be deduced from data given in this volume are certainly illuminating. "Russia is one of the world's most important oil countries!", it is stated. Figures of crude oil production quoted show that, at least from 1948 until 1952 inclusive, the U.S.S.R. stood third in world order, the United States and Venezuela being first and second respectively. One of the most significant sections of this book (Part 2) reveals how this position has been consolidated, judged on a purely technical basis. Up to 1946 all exploratory work for petroleum in the Union was controlled by the Chief Administration for Geology and Geodesy of the Supreme Economic Council, which then became the Ministry of Geology, with the task of co-ordinating all geological work for the discovery and recovery of the rich mineral resources of the Soviet Union. In this context the statement that by "the planned co-operation of the state, the economy, and science, three quarters of the entire area of the Soviet Union had been geologically explored up to 1947" is somewhat surprising. It is estimated that more than one thousand geological–geophysical prospecting units, well equipped, are working in exploration of mineral resources (including petroleum), particularly in the central and peripheral regions of the Union. Considering the enormous size of territory involved, the programme ahead, even allowing for what has already been accomplished, must be a staggering problem for the Ministry concerned; one would have thought that considerably more than one-quarter of the Union awaited pioneer developments, especially in eastern provinces and more northerly latitudes.

This is not the only problem, however. The author is concerned with the future oil demand of the Soviet Union and states his conclusion that "Russian oil supply is the Achilles' heel of the Soviet economy". From this stem arguments that indigenous oil supplies have not risen as rapidly as production in the United States and elsewhere in the world, nor even with demands of Soviet industrial production; that imports of oil from countries within the orbit of the political and economic influence of the U.S.S.R., because of their individual demands, cannot make up a major leeway. Sinkiang, the East Chinese province, is a potential external source, dependent on positive economic developments foreshadowed in the Russo–Chinese treaty of 1950; but results of this exploratory work in terms of direct exports of oil from this source to the U.S.S.R. are, so far as is at present known, vague. Thus, "the core of the Soviet oil industry will always be the Russian oil fields", a conclusion leading to a searching epilogue to this seemingly well-informed book.

So inevitably, as others have done before him, Dr. Hassmann detaches his theme from the U.S.S.R. and translates the economics he has been at such pains to expose via "Alpine regions of world politics" into the unpredictable future of Middle East oil production. Iran, Iraq, Saudi Arabia, Kuwait, Qatar and Bahrein Island—herein concentrated are estimated to lie more than 40 per cent of the total world oil reserves: a fabulous oil area on the threshold of the U.S.S.R. The author leaves the reader in no uncertain doubt of his interpretation of the issues at stake. If circumstances should ever place Middle East oil (believed to be capable of exceeding one hundred million tons in a matter of years) under Soviet control, then this colossal increment to her indigenous production implies such increase in economic power of the U.S.S.R. as would shake the whole world political situation. However, at this point, we may profitably return to the foreword, wherein that eminent petroleum technologist, E. de Golyer, joins issue. Just as the Middle East is vulnerable to military attack, de Golyer argues, so is the Baku region, the chief present source of Russian oil. "Clearly the strategy of the Soviet Union calls for the building up of a less vulnerable source of supply in the interior of Russia, and to this end the Soviets appear to be concentrating their efforts". Whichever way one contemplates the situation and whatever the future may unfold in fields of nuclear energy, petroleum is still a major force in power politics.

H. B. MILNER

Witchcraft Today

By Gerald B. Gardner. Pp. 163+4 plates. (London: Rider and Company, 1954.) 12*s.* 6*d.* net.

THIS interesting and unusual book appears to be the first of its kind. Written by Dr. G. B. Gardner, the director of the Museum of Magic and Witchcraft in the Isle of Man and a member of one of the few covens of the witch cult left in Britain, it sets out to describe how the practices of modern witchcraft are connected with the ancient rites and how they may be compared with the revelations concerning them which were brought to light in the witchcraft trials. Dr. Gardner writes with a disarming simplicity. He shows himself perfectly aware of the difficulties, the contradictions and the apparent absurdities of witchcraft as it is generally understood. Yet, as Dr. Margaret Murray indicates in her admirable introduction to the book, much remains of great interest and psychological importance. The rhythmic movements and chants in which numbers of persons take part induce both exhilaration and at times even a kind of intoxication, during which gratitude is extended to the Creator for his goodness and hope is expressed for its continuance.

Far from deriding the existence of the witch 'power', Dr. Gardner is at pains to link it up with what is known about suggestion, extra-sensory perception and even radiæsthesia. In the course of his discussion he shows clearly where the pitfalls lie and, while expressing his own tentative views on these controversial matters, never irritates the reader by propaganda designed to convert him to unreasoning belief. The book is well produced with a useful list of references; but unfortunately there is no index. It is to be recommended to all who wish to learn something of the meaning of witchcraft as it is to be understood to-day and interpreted through the help of modern followers of the cult. E. J. Dingwall

Encyclopedia of Chemical Reactions

Compiled and edited by C. A. Jacobson, with the assistance of Clifford A. Hampel and Elbert C. Weaver. Vol. 5: Nickel, Niobium, Nitrogen, Osmium, Oxygen, Palladium, Phosphorus, Platinum, Potassium, Praseodymium, Radium, Rhenium, Rhodium, Rubidium, Ruthenium. Pp. viii+787. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1953.) 120*s.* net.

THE fifth volume of this encyclopædia follows the same pattern as that of previous volumes. It covers, in alphabetical order, all the elements from nickel to ruthenium excepting protoactinium and radon. Actually, only a few reactions are listed for radium, rhenium and niobium. The inclusion of niobium seems unfortunate considering that a larger number of its reactions have already been listed under columbium. Like some of the earlier volumes, the present one gives the same impression of untidy carelessness and poor editing. For example, the few reactions given under rhenium are all taken from a published lecture and no reference is made to the actual discoverers of the reactions; the impression is therefore given that the lecturer is the originator of the reactions. There is also some carelessness in regard to nomenclature, as, for example, when $(PNCl_2)_3$ in one abstract is called phosphorus chloronitride, while in the next it is phosphorus dichloride nitride; $(PNCl_2)_4$ is given the more workman-like name of tetraphosphonitrilic chloride. In addition, there are a number of printing errors.

Although this encyclopædia is extremely useful, ones does feel that its value would have been greater if, instead of the haphazard abstraction of chemical reactions from any journal which happened to be handy, a directed and determined effort had been made to provide a reasonably complete list of the reactions of the various elements.

G. R. Davies

Metallurgical Abstracts

General and Non-Ferrous. Volume 20, 1952–53 (New Series). Edited by N. B. Vaughan. Pp. iv+602. (London: Institute of Metals, 1953.) 60*s.*

THE service offered by the well-known "Metallurgical Abstracts" is outstanding. For a modest sum a bird's-eye view, as it were, of world progress in a large part of metallurgical science and practice is provided. The specific scope cannot be defined with precision in a few words, but broadly it consists of the general theory of the metallic state, and the science and practice of non-ferrous metallurgy (excluding mining and extraction), together with many associated subjects.

The abstracts are informative rather than merely indicative, which is a great advantage especially with foreign publications, although it naturally involves a greater delay in publication than with the indicative kind. The reviewer can testify, from personal use, to the general reliability of the abstracting. There are twenty-three subject headings, and this is generally satisfactory, except for physical metallurgy, the bulk of which subject is found under three headings; these are too few, and considerable work could be avoided for users if more subdivision were used. The matter is presented in good print on very suitable paper, and is thoroughly indexed with respect to names and subjects. A. R. Bailey

Exercises in Theoretical Statistics

With Answers and Hints on Solutions. By Prof. M. G. Kendall. (London: Charles Griffin and Co., Ltd., 1954.) 20*s.*

THIS collection contains four hundred exercises, taken mainly from examination papers and research journals, and it represents yet another example of the prodigious labours of Prof. M. G. Kendall, for which statisticians have already much reason to be grateful. He has not attempted to cover all the applications of statistics, but has concentrated on basic theory, dividing the exercises into five groups, namely, distribution theory (100 exercises), sampling theory (100), relationship (75), estimation and inference (75) and times series (50). Not all will agree with the classification he has employed; in particular, the line of demarcation between the first two groups is rather indefinite, while exercises on the evaluation of moments appear in all groups. Because of the close integration between courses of lectures and the examination questions to which they lead, published examination papers tend to look even harder to others than they did to their intended recipients. Thus, the student working on his own would gain little help from standard texts in attempting, for example, the elegant series of problems on the theory of queues for which Cambridge 1948 was such a vintage year. Prof. Kendall has now largely overcome this difficulty by the outline solutions at the end of the book, which make it invaluable to student and teacher alike.

R. L. Plackett

THE 15-MeV. LINEAR ACCELERATOR AT ST. BARTHOLOMEW'S HOSPITAL

By Prof. J. ROTBLAT

An electron linear accelerator has recently been completed by the Mullard Research Laboratories and installed in a temporary building adjacent to the Physics Department of the Medical College of St. Bartholomew's Hospital, London. The accelerator, which was purchased from the Hospital Discretionary Fund, will ultimately be employed for treatment; but during the next few years it will be used entirely for research work in fundamental studies on the action of radiations on living tissue, on new techniques in radiotherapy, and on some problems in nuclear physics.

The accelerator is of the travelling-wave type. It consists essentially of two parts, each containing three one-metre sections of corrugated wave-guide and a feed-back system. The radio-frequency power is derived from one magnetron, and is split to supply the same amount of power to each part. The design of the machine is very similar to that of the linear accelerator at Harwell, the details of which were described by Bareford and Kelliher[1], with the exception that the feed-back bridge in the rectangular wave-guide is of the 'rat-race' type instead of the circular 'magic tee', and that in the second part the corrugated wave-guide was modified to have a ratio of a/λ (a, radius of the iris in the guide; λ, wavelength) of 0·150, instead of 0·168 as in the first part. As a result of this modification, both the final energy and the efficiency of the machine were significantly increased.

In order to check the performance of the accelerator, measurements have been made of the energy of the electrons in the emerging beam, using a magnetic deflexion method, and of the mean power in the beam, using a water calorimeter. The graphs of Fig. 1 show the variation of the electron energy and of the pulse current with the gun filament current, which is a measure of beam loading. The pulse current was calculated from the mean current, assuming that the duration of each pulse was 1·3 μsec. It is seen that a usable current is obtained even at an energy greater than 16 MeV. The optimum output is obtained at an energy of about 14 MeV., when the pulse current is 50 milliamperes. With an input pulse power from the magnetron of 1·8 megawatts, this corresponds to a pulse efficiency of about 40 per cent; the mean efficiency (ratio of mean beam-power to mean radio-frequency power) is about 25 per cent.

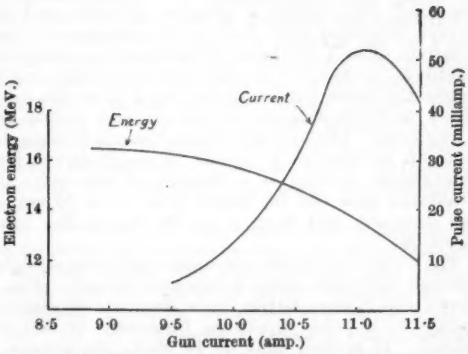

Fig. 1. Electron energy and pulse current as a function of beam loading (from measurements made at the Mullard Research Laboratories)

For therapy purposes the linear accelerator has been provided with an X-ray head (Fig. 2), in which the electron beam coming out from the wave-guide can be bent through 90° by means of an electromagnet. In addition, the whole head can be rotated in a plane normal to the axis of the accelerator through an arc of 140°, so that the beam can emerge in any direction from 20° on one side of the downward vertical to 30° above the horizontal. For experimental purposes the electron beam can also be made to emerge in the straight-through direction; Fig. 3 shows a photograph of the electron beam emerging into the air through a beryllium–copper window.

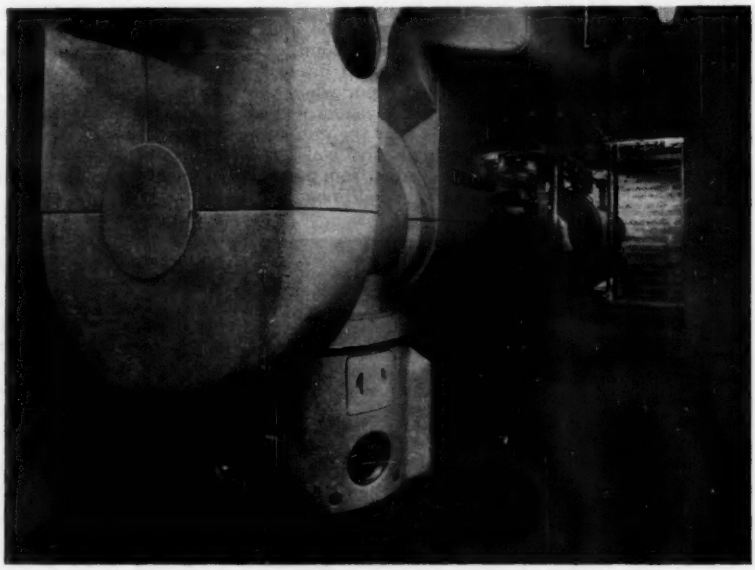

Fig. 2. X-ray head

In order to be able to select the different types of radiations which can be produced, the X-ray head contains a target holder which can be located in any one of three positions. In the first, there is no target and the electrons emerge directly into the air. In the second, they are made to strike a platinum target, resulting in the production of an X-ray beam. In the third, they strike a uranium cylinder, and the X-rays produced give rise to the emission of fast neutrons. The X-ray head contains several ionization chambers, to monitor the dose and dose-rate, and to centre the beam automatically, as well as the usual filters and diaphragms to flatten and define the X-ray beam. The aperture of the beam is rectangular and can be varied, by means of motor-driven lead diaphragms, so that at a distance of one metre the irradiated area can be varied from 0 to 20 cm. in one direction and from 3 to 28 cm. in the other direction.

The output of X-rays was measured in the straight-through direction using a tungsten target. Fig. 4 shows the X-ray output as a function of electron energy at a pulse repetition frequency of 500 per second. It is seen that at 14 MeV. the output is 3,300 r. per minute at 1 metre, decreasing to 1,100 r. per minute at an energy of 16 MeV. After passing through the filters and diaphragms the X-ray output will probably be reduced by a factor of about 3, but even then it will still be considerably greater than that available from any other radio-therapy set.

The very high output of radiations from the accelerator means that for many experiments the time of exposure would be very short; in fact, too short to be controlled by mechanical devices. For this reason, a new method for terminating exposures has been devised, namely, by means of a predetermined number of pulses. A special electronic device using dekatron tubes was designed and built which enables one to give an exposure consisting of any preset number of pulses, from 1 to 10,000. For many radiobiological experiments, single pulse exposures will be sufficient and a separate facility for this is provided. It is also possible to vary the pulse repetition frequency from 10 to 500 per second.

In order to avoid possible variations of intensity in the individual pulses, which may occur when the radio-frequency is switched on, the accelerator was modified to include deflecting coils near the gun end. When a current is flowing through the coils, the electron beam is deflected and prevented from passing along the accelerator until stable conditions have been attained. The effectiveness of the deflecting system was checked by measuring the X-ray output when the gun and radio-frequency were on at full power and the beam deflected, and comparing it with the output given by the undeflected beam. The ratio was found to be 1 in 30,000; it may be possible to reduce this ratio still further.

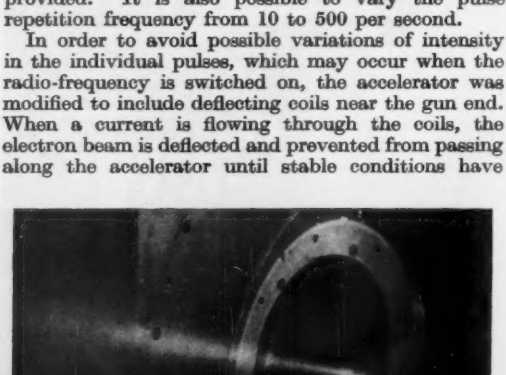

Fig. 3. Beam of electrons emerging from the X-ray head

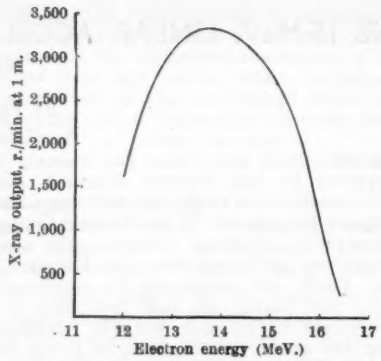

Fig. 4. X-ray output, at 500 pulses per second, as a function of electron energy

In the research programme, experiments have already begun on a number of problems. In the X-ray work, depth-dose determinations are being made as well as other measurements necessary before treatment can begin. In addition, experiments are being carried out to determine absolutely the energy deposited by the X-rays in tissue, using a calorimetric method. The properties of the electron beam are being investigated with the view of using it for electron therapy. Electrons of an energy of 15 MeV. have a range of 3 in. in tissue, and there are definite advantages in using such electrons chiefly due to their finite range. Similar studies are being made with the neutrons, in order to explore the possibilities of neutron therapy. The nuclear physics experiments are mainly concerned with photo- and electron-disintegrations; the emission of photo-neutrons and photo-protons, and the production of radioactive isotopes, are being studied using several techniques.

The main feature, however, of the linear accelerator which makes it particularly suitable for radio-biological research is its capability of delivering momentary doses of radiation at an exceedingly high rate. When tuned to optimum output, each pulse contains about 4×10^{11} electrons. Since the whole of the emerging beam is contained in a circle of 1 cm. diameter, this means that to a limited volume one pulse of electrons can deliver a dose of more than 15,000 r. This feature opens up the possibility of studying effects caused by radiation within a very short time interval after it has been delivered, since even one pulse of radiation is sufficient to produce an observable effect. Apart from the study of the kinetics of various radiation reactions, the effects resulting from the application of very high dose-rates lend themselves to investigation, for with a pulse duration of 1·3 μsec. the dose-rate in the pulse can reach a value of 7×10^{11} r. per minute. Even when using multiple pulse exposures, the average dose-rate can be as high as 5×10^{8} r. per minute.

Among the experiments to be carried out in radio-biological research is an attempt to measure the life-time of free radicals formed in irradiated liquids,

by means of their absorption spectra. For this purpose, pulsed light sources have been developed which give intense flashes of light of about 1 μsec. duration. These flashes will be synchronized with the pulse of radiation so as to obtain a series of absorption spectra at various intervals after the irradiation. In order to analyse the spectra, a high-speed rotating mirror with frictionless bearing has been built. In another series of experiments the effects of radiations on tissue enzymes are being studied, and experiments are in preparation for the investigation of the relationship between dose-rate and biological effects on the living cell by the use of the tissue-culture technique.

[1] Bareford, C. F., and Kelliher, M. G., *Philips Tech. Rev.*, **15**, 1 (1953).

RELAXATION AND FLOW IN GLASSES

THE British Society of Rheology held a symposium at Queen Mary College (University of London) on January 28 on the subject of "Relaxation and Flow in Glasses". The theme was introduced by Prof. G. O. Jones (Queen Mary College), who gave an account of the nature and physical properties of 'glass'—using the term in its broadest connotation to cover such substances as glycerol, glucose, water, ordinary inorganic glasses and silica, having widely differing chemical behaviour. In this sense the term has essentially a thermodynamic significance, and it is constructive to approach the study of glasses from this point of view.

In the thermodynamic hierarchy, glass is a doubly unstable liquid, the progress of which towards stability is inhibited because of its high viscosity. It is, first, unstable relative to any ordered crystalline state and will, under certain conditions, crystallize or 'devitrify'. However, in normal use, this does not occur. Of greater physical significance in the study of glass is its instability relative to the state of internal equilibrium which corresponds to ordinary supercooling of a liquid. The temperature at which the viscosity is 10^{13} poise (the 'transformation temperature', T_g) marks a rough boundary above which a glass-forming system is merely a supercooled liquid and below which it is a glass. At any temperature below T_g, the glass takes a finite time to reach the state of internal equilibrium corresponding to the particular temperature. The progressive approach to this state—often described as 'stabilization'—is normally shown macroscopically as a contraction. The significance of the figure 10^{13} is only that for most substances it corresponds to a Maxwell relaxation time of the order of the duration of ordinary experimental observations. As the temperature is lowered below T_g, the microscopic adjustments necessary for the attainment of the configuration appropriate to the actual temperature take longer and longer times. This has great practical significance in the manufacture of optical glass.

The rheological properties of a glass are of special interest since they can be assumed to imitate—but in slow motion—those of ordinary liquids. The reactions to an applied shear stress consist of a reversible elastic contribution—partly instantaneous and partly delayed or 'relaxing'—and an irreversible portion which is Newtonian viscous flow. Under a uniform compressive stress, there is, of course, no viscous flow, but again the two reversible reactions appear. The almost exact formal correspondence between the delayed reaction in this case and the process of stabilization is of special interest.

By varying the temperature, the relative importance of the separate reactions to applied stress may be varied, and they can be studied individually by simple methods. At temperatures well above T_g, only the viscous flow is normally of importance. Near T_g the three types of reaction are of about equal magnitude in the time-scale of ordinary observations, and this gives rise to the possibility of observing frozen-in stresses between adjacent layers when glass in which a temperature gradient exists is cooled through the neighbourhood of T_g. The removal of these stresses (often known as 'strain') is the main function of 'annealing' processes in commercial glassware.

At sufficiently low temperatures the instantaneous elastic strain preponderates over the other reactions to applied stress, and glass (though still thermodynamically an unstable liquid) becomes in its mechanical properties the model of a brittle solid.

Mr. R. W. Douglas (Research Laboratories, General Electric Co., Ltd., and professor-designate of glass technology in the University of Sheffield) spoke of his work in collaboration with Mr. J. O. Isard on the density of fused silica near T_g, where, of course, physical properties may be functions of time as well as of other parameters. Because of its high transformation temperature (about 1,200° C.), silica has previously been somewhat inaccessible to such studies, and special methods have to be used. The typical experiment here consisted of heating the specimen of silica for a given interval at constant temperature, cooling quickly by withdrawing it from the furnace, and then measuring its density at room temperature. The specimen was again placed in the furnace and the whole process repeated until the measured density showed a constant value. A density thus measured contains, of course, a contribution from the thermal contraction during cooling to room temperature, and the coefficient of expansion governing this would be expected to change with time. In order to be able to make use of these measurements at room temperature to estimate the density at the original heating temperature, it was necessary to determine separately the effect of the heat treatment on the coefficient of expansion. The results show that this contribution accounts for about half the observed change in density.

The corrected equilibrium densities were found to increase as the temperature was increased in the range 1,050°–1,300° C., indicating that here fused silica has a negative coefficient of expansion if sufficient time is allowed for the atomic configuration to reach equilibrium. This behaviour appears to be analogous to that shown by water between 0° and 4° C., where the increase in density with rising temperature is attributed to the collapsing of the directed bonds. The well-known fact that the equilibrium configuration in glasses can be approached from both sides was demonstrated in these experiments for the case of silica.

Mr. Douglas went on to describe experiments on the release of mechanical stress in silica. It has long been known that the release of stress in glasses—for example, in annealing processes—does not follow the behaviour of the simple Maxwell body. Deviations from this behaviour must be partly due to the variation of viscosity with time and partly to the influence of delayed elastic (or visco-elastic) con-

tributions. Since the rates of approach to equilibrium in silica near T_g have been established from the experiments on density changes, an attempt was made to estimate how far the deviations from Maxwellian behaviour are due to varying viscosity by making measurements of the release of stress from time to time during the slow approach of a specimen of silica towards its equilibrium configuration. The specimen consisted of a thick-walled cylinder in which a slot had been cut. The stress could be introduced by inserting a wedge of fused silica into this slot, and the magnitude of the stress determined by observing the birefringence. The rate of release of stress (at constant strain) was found to decrease when the specimen was heated. Eventually it reached a constant value after a time about equal to that which had been found necessary for the attainment of the equilibrium density at the same temperature. However, even at equilibrium, the release of stress did not follow the pattern expected from a Maxwell body, and an important contribution from viscoelasticity appeared to be present. The experiments were not regarded as decisive because it was found that as the material approached equilibrium it appeared to become more and more inhomogeneous. This behaviour was attributed to the fact that the viscosity after first cooling from a high temperature would have nearly the same value throughout the specimen, but as the configuration reached equilibrium, differences in viscosity due to physical inhomogeneities might become more marked.

Dr. R. O. Davies (Queen Mary College) spoke of the possibility of giving a thermodynamic treatment of the process of attaining configurational equilibrium (or stabilization).

In order to do this, one must assume that the instantaneous state is fixed not merely by the pressure and temperature (say) but by one or more internal ordering parameters as well. The principle involved is not new, but has been used in chemical thermodynamics since the time of Gibbs. (In chemistry the internal parameters are 'degrees of reaction', describing the progress of chemical changes which can take place in the system.) With glasses the simplest procedure is that due to Tool, who introduced and used a 'fictive temperature' ($\bar{T}$), giving a measure of the internal state of the glass. When $\bar{T}$ is equal to the real temperature (T), the glass is in thermodynamic equilibrium and has its equilibrium structure; when it is not, the structure is that of a glass which would be in equilibrium at a temperature higher or lower than T (according as $\bar{T}$ is greater or less than T).

Alternatively, a 'fictive pressure' might be introduced. This is especially convenient in the discussion of experiments in which the pressure on the glass is varied, and can be used to give a qualitative explanation of some aspects of the recent experimental observations of P. W. Bridgman and I. Šimon on volume changes in glass at very high pressure.

Tool's idea can be fitted into a rigorous thermodynamic formalism which—with appropriate extensions—should be applicable to any isotropic process in glasses. The main results for a single ordering parameter are: (*a*) a set of thermodynamic relations connecting the properties of a glass with those of the corresponding equilibrium liquid, (*b*) a means of predicting the kinetic behaviour under various experimental conditions (for example, isothermal–isobaric, adiabatic–isobaric, etc.) in terms of that observed under any one set of conditions.

Experimentally it is found that in no case which can be checked are the predictions under (*a*) exactly fulfilled. Those of (*b*) have never been tested. The reason for the failure of (*a*) is that one ordering parameter is not enough. This is especially conspicuous in the special case of borosilicate glass. To remedy this, more parameters must be introduced, and the limiting case is that of an infinity of parameters and a continuous distribution of relaxation times. Thus the thermodynamic theory becomes similar to the treatment of the general isotropic response of a linear body—a problem familiar to rheologists. The thermodynamic approach is, however, more flexible and attractive than the purely mechanical treatment.

It is clearly desirable to extend the thermodynamic treatment so as to deal with shearing motion as well. Here a curious situation appears. We should like to be able to exhibit delayed elasticity and flow as a special case of stabilization. It is possible to deal with delayed elasticity provided we exclude permanent deformation and admit a tensorial degree of order instead of a scalar quantity. Alternatively, it is possible to derive the Stokes–Navier equations for the case where there is no delayed elasticity but only permanent deformation. But the central problem of combining both reversible and irreversible fluidity within a single thermodynamic framework seems to be more difficult.

PROJECT 'SHOWER': AN INVESTIGATION ON WARM RAIN IN THE HAWAIIAN ISLANDS

By P. SQUIRES

Division of Radiophysics, Commonwealth Scientific and Industrial Research Organization, Sydney

ONE of the most interesting problems in the subject of the physics of rain is posed by rain which falls from clouds wholly warmer than freezing, often called simply 'warm rain'. The classical theory of the formation of raindrops expounded in 1933 by Bergeron envisaged a cloud of supercooled water droplets in which, as cooling proceeded, ice crystals began to form, usually at temperatures around −10° to −15° C. However, over the past ten years or so, many cases of 'warm rain' have been reported, and, after some hesitation, its existence is now universally accepted.

The basic problem in the formation of this sort of rain is to explain how a single cloud process can sometimes give rise to two families of drops: on one hand, cloud drops, and on the other, raindrops which are of the order of 10^6 times greater in mass. Some quite drastic form of selection in favour of a few of the droplets seems to be indicated. In the Bergeron process the singular character of the ice crystal in a cloud of supercooled water provides a key which seems adequate. In warm clouds it is not obvious what determines the selective growth of a small number of drops.

Condensation nuclei vary widely in size and effectiveness. This no doubt causes some cloud droplets, formed on the larger or more effective nuclei, to outgrow others. Nevertheless, it is generally agreed that this effect is quite inadequate to explain

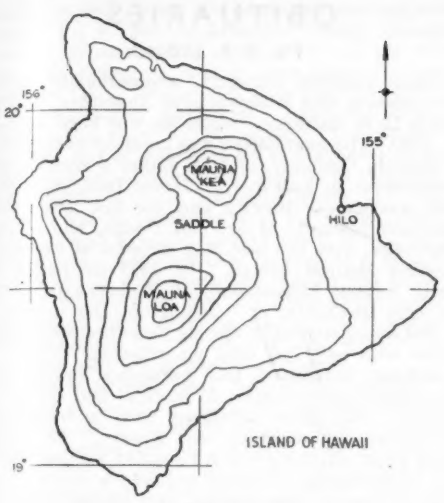

Fig. 1

the growth of raindrops in a cloud. If this is so, the raindrops must gain most of their water by colliding and coalescing with cloud drops. Computations have been made, by several authors, of the growth of a raindrop by this process, starting off from a somewhat bigger-than-average cloud droplet which as it fell through the cloud collected some of the droplets in its path. The view has been advanced that some of the giant sea-salt nuclei observed by Woodcock could outgrow the vast majority of the smaller nuclei and so provide the 'singular' particles which grow eventually to raindrops.

It is now well known that warm rain is very common in tropical maritime climates. A. H. Woodcock, of the Woods Hole Oceanographic Institute, has spent two periods of several months in the Hawaiian Islands during the past two years, studying the relation between sea-salt nuclei and warm rain. The advantages of these Islands for such studies are indeed striking. Lying in lat. 19°–22° N., they are subject most of the time to the Trade wind. For 2,000 miles around, there is no land except other small oceanic islands. The islands of Oahu and Hawaii have a simple topography: Oahu consists primarily of a 3,000-ft. ridge lying almost across the stream of the Trade wind, and Hawaii of two cone-shaped mountains, Mauna Kea and Mauna Loa, as shown in the map (Fig. 1); each of these reaches very nearly to 14,000 ft. Their slopes are gradual and extraordinarily regular. Between them is a 6,500-ft. saddle, thirty miles wide. The line of the peaks is very nearly north–south. The easterly stream of the Trade wind is broken here into three branches, one passing north of the Island, one south, and one through the saddle. A good road runs west from the city of Hilo on the east coast up through the saddle (about thirty miles away), so that measurements can be taken on the orographic rain which falls on this slope of the Island when the Trade wind is fairly strong. Finally, the airport at Hilo has full facilities, and the density of air traffic is not such as to cause inconvenience to experimental aircraft operating in the area.

The idea of a joint international project in Hawaii was sponsored by A. H. Woodcock, of Woods Hole, and by W. A. Mordy, of the Meteorological Department of the Pineapple Research Institute of Hawaii and the Hawaiian Sugar Planters Association in Honolulu. The Office of Naval Research of the U.S. Navy provided funds to the Woods Hole Oceanographic Institute for the purpose, and the Radiophysics Division of the Commonwealth Scientific and Industrial Research Organization was invited to participate. Several other organizations were represented as well. The research workers who eventually assembled at Hilo early in October 1954 were: A. H. Woodcock, D. C. Blanchard and A. T. Spencer, from the Woods Hole Oceanographic Institute; W. A. Mordy, L. Eber and D. S. Johnson, from Mordy's Honolulu group; E. Eriksson, of the Institute of Meteorology, University of Stockholm; V. J. Schaefer, of the Munitalp Foundation; E. J. Workman and B. K. Seely, of the New Mexico Institute of Mining and Technology; C. E. Junge, of the U.S. Cambridge Air Force Research Center; E. A. Amman, of the U.S. Weather Bureau; J. Warner, P. Squires and S. Twomey, of the Division of Radiophysics, Sydney, of the Commonwealth Scientific and Industrial Research Organization. The U.S. Weather Bureau gave full co-operation, arranging for six-hourly radiosonde and rawind observations at Hilo, besides attaching a full-time meteorologist (E. A. Amman) to the project. The whole group was very conveniently housed in the National Guard Officers' Club alongside Hilo airport. Three aircraft were used: two light aircraft provided and flown by the agricultural aviation firm of Murrayair, and a Royal Australian Air Force Dakota flown from Australia and operated in Hawaii by an R.A.A.F. crew of six.

The Woods Hole group was equipped to measure sea-salt nuclei from aircraft and raindrop spectra on the ground. Mordy's Honolulu group undertook most of the ground observations, such as rainfall and pilot balloon observations. Schaefer and Workman were concerned with atmospheric electricity, Seely with measurements on sea salt using the sensitized gelatine strip method. Junge made measurements of the trace constituents of the atmosphere, and Eriksson of the salt and nitrogen content of rain samples collected by the Woods Hole and Honolulu groups. Warner and Squires were equipped to measure the liquid water content and temperature of clouds, and the spectra of droplets in them. Their Dakota aircraft was also equipped with 10-cm. radar for observing the distribution of rain in clouds. Twomey was concerned with measuring (on the mountain-side) the spectrum of raindrops and the charges on cloud drops.

Two themes were adopted as a basis for the measurements. Woodcock had earlier found evidence of a remarkable relationship between the salt content of the clear air over the sea, and that of the rain which fell on the windward slope of the Island. Accordingly, with Blanchard and Eriksson, he took samples of airborne sea salt over the sea on each day when the Trade Winds blew, and made measurements on the spectrum of the raindrops falling on the mountain-side and on the bulk salinity of rain samples taken over short periods by means of a large (1 m.^{2}) funnel. Eriksson also analysed these samples for nitrogen, and the comparison of his results with Junge's promised to be fruitful.

The remaining resources of the project were not directed to any particular aspect of the problem of warm rain. On the contrary, the aim was to get as

complete a picture of the whole process as possible. The objective chosen to give coherence to the observations was the simplest one that came to mind: to concentrate all the observations on the central stream of the Trade Wind which climbs up the mountain-side and passes through the saddle; to measure the properties of the air as it crosses the coast and again as it debouches through the saddle, and to see whether the depletion of its water vapour and sea-salt content could be related to the amount of rain which fell on the slopes, and to the salinity of the rain. The Trade Wind inversion provided a convenient and easily recognized upper boundary to the mass of air involved in the experiment.

This 'budget' operation, as it was called, required the co-operation of many people. On one day, the mass of air chosen for investigation was that which crossed the coast between 1 p.m. and 3 p.m. It was estimated that it would take two hours to reach the saddle, so that it would be passing out of the experimental area between 3 p.m. and 5 p.m. Between 1 and 3 p.m., two light aircraft patrolled offshore, and observations were taken of the sea-salt spectrum, the temperature and humidity of the air, and the water content of clouds, up to the base of the inversion. During the same period, pilot balloons were run at stations along the coast in order to determine the boundaries of the stream which converged into the saddle. At 1 p.m. observers set off on two parallel roads towards the saddle, emptying and rinsing out the hundred rain gauges which had been set out at intervals of a mile apart. They aimed at reaching the saddle at 3 p.m.; at that time other observers followed up along the same roads, measuring the rain which had fallen in the two-hour period and taking samples for salinity determinations; they aimed at arriving at the saddle area at about 5 p.m. At 2.30 p.m. the Dakota aircraft took off, climbed over the sea, taking soundings of temperature and humidity, and then went inland above the orographic cloud to the saddle. Here there was usually a clear space, and a sounding was made as low down as possible, usually to within 500 ft. of the ground, measuring temperature, humidity and sea-salt content. The Dakota continued observations until 5 p.m., alternately sounding in the saddle area and making runs down the mountain-side to Hilo in the orographic cloud, at fixed ground clearances, usually 1,000 and 2,000 ft. On these runs the liquid water content and droplet spectra of the orographic cloud were observed. During the period 1 p.m.–5 p.m., the spectrum of the raindrops was observed at two levels on the slope, and electric charges on cloud droplets at one level. A 10-cm. and a 3-cm. radar observed the motion of showers; cameras on the upper slope of Mauna Loa recorded the motion of the cloud tops, and anemometers at the coast, on the slope, and in the saddle measured the run of the wind.

Despite an unusually fine stretch of weather during November, a great deal of information was gathered. Several months will be needed to reduce all these observations to tabular form for publication later this year.

The burden of the many detailed arrangements for so large a group of people inevitably fell on the Honolulu group who acted as hosts; without their efficient organization of accommodation, transport and the like, much less would have been achieved. Excellent co-operation was given, too, by the aeronautical and defence authorities at Hilo Airport, and by the people of Hilo.

OBITUARIES

Mr. J. F. Didusch

James Francis Didusch, internationally known as a medical and embryological illustrator, died on March 16 in Baltimore, where he was born on June 17, 1890. His grandfather was an artist-lithographer in Munich, Germany, and his father a sculptor and wood-carver in Baltimore. James Didusch studied both mechanical drawing and the fine arts at the Maryland Institute of Art and Design, and medical illustration with the late Max Broedel at the Johns Hopkins Medical School. In 1913 he joined the newly formed Department of Embryology of the Carnegie Institution of Washington, and worked in its Baltimore laboratory during his entire professional career with only one brief interruption.

Didusch illustrated the researches of the distinguished embryologists, F. P. Mall and George L. Streeter, and their colleagues with a remarkable combination of accuracy and beauty. He would never draw anything which he could not see clearly and comprehend. Thus he acquired a sound knowledge of human development, and himself became a contributor to the precision and clarity of work published from the Department and sometimes an anonymous colleague in the research. Although from time to time he also illustrated clinical books and articles, his real life-work is in the successive volumes of the Carnegie Contributions to Embryology. Among hundreds of drawings, it is difficult to choose those which best illustrate his beautiful style. Notable among his early work are the plates for L. H. Weed's monograph on the cerebro-spinal spaces (vol. 5) and for Florence Sabin's article on the primitive blood vessels (Vol. 6). Later on he drew a series of pictures of important human embryos which have become classics of embryological art and are widely copied in the text-books, the finest of all perhaps being the lateral view of a 10-somite embryo, Carnegie 5078, in Volume 20 of the Contributions. A special talent for clear and simple diagrammatic representation without losing the similitude of animal tissues is shown by a page of diagrams illustrating the placentation of the rhesus monkey, Vol. 27, p. 9. Even in the last volume published in his lifetime (Vol. 35) the drawings for L. J. Wells's monograph on the diaphragm, made when his health was already failing, show his characteristically firm touch in line drawing and his refined half-tone style. Didusch carried his zeal for perfection all the way to the press-room, where he often supervised the inking of the rollers or helped mix the colours so that the drawings would be properly printed.

Mr. Didusch was a man of very sociable disposition. Loving good music, good food and a good story, he endeared himself to all his fellow workers, who will remember him as a generous friend as well as a stimulating collaborator and one of the greatest scientific illustrators of his time.

George W. Corner

Mr. W. R. Sherrin

William Robert Sherrin was born at Twickenham on May 20, 1871, and died at South Norwood, London, on March 22 after a long failing in health. He was a son of John Sherrin, R.I., from whom he inherited a skill of hand, brush and pencil. As a boy he was sickly, and an outdoor life was prescribed:

partly for this reason his education was neglected, though, for a time, he attended Taplow Grammar School. When he was eight years old his family moved to Ramsgate, and he soon began to wander about the Isle of Thanet and became an avid collector of natural history specimens. Later, he opened a taxidermist's shop at Ramsgate. His ability at mounting and at dissection led to his appointment in 1895 as an articulator in the Zoological Department of the British Museum (Natural History). His health by then had so improved that for many years he cycled to and from Southend-on-Sea, where he had gone to live; until recently he rose at 4 or 5 a.m. and worked at whatever extra task he had on hand. He was employed in the Zoological Department of the Museum until 1928, his manipulative excellence being signalized by the naming after him of a rat from Sind and a bat from New Guinea.

In 1919 Sherrin was appointed curator and secretary of the South London Botanical Institute. This Institute at South Norwood, with a large and valuable herbarium and library, was founded by A. O. Hume in 1911, "to promote, encourage, and facilitate amongst the residents of South London, the study of the science of Botany". To some this appointment was surprising; but Sherrin was a well-known amateur botanist with a special interest in grasses, sedges and, more particularly, mosses. He was attracted to mosses because they were so often used as packing for zoological specimens: the frequency of *Sphagnum* may have led to his study of this difficult genus, on which he published "An Illustrated Handbook of the British Sphagna" in 1927.

No longer able to put in full time at the British Museum, he worked from 8 a.m. to 12 noon. In 1928, at his request, he was transferred to the Department of Botany to take charge of the moss collection after A. Gepp's retirement. He continued there until 1947, and on leaving the Museum was awarded a Civil List pension.

Sherrin was highly successful at South London, applying himself with energy and devotion to running the Institute. He was a born teacher—though not a good lecturer—and had an inspiring and helpful influence on young and old seeking a knowledge of plants, as several who became eminent botanists have testified. The field excursions which he regularly conducted were of great value not only to adult members of the Institute but also to university students and others who found stimulus and satisfaction in his knowledgeable enthusiasm.

He was elected an associate of the Linnean Society of London in 1910, and recently a life-member of the Zoological Society. He served as president of the British Bryological Society during 1947–48.

J. RAMSBOTTOM

NEWS and VIEWS

Sir German Sims Woodhead, K.B.E. (1855–1921)

GERMAN SIMS WOODHEAD, who was born one hundred years ago on April 29, 1855, came of old Yorkshire Quaker stock, and was educated at Huddersfield College and then at the University of Edinburgh, where he graduated in medicine in 1878, taking his M.D. three years later. After postgraduate studies in London, Berlin and Vienna he became demonstrator of pathology at Edinburgh under W. S. Greenfield and superintendent of the research laboratories of the Royal College of Physicians of Edinburgh. In 1890 he was appointed director of the Conjoint Board's laboratories in London. In the *Lancet* laboratory Sims Woodhead investigated incandescent gas lighting, the flashpoint of lamp oils, and the standardization of disinfectants. In the early days of diphtheria antitoxin he placed its manufacture in Great Britain on a sound basis. As assistant commissioner of the Royal Commission on Tuberculosis, he became a recognized authority on that disease, and with P. C. Varrier-Jones he founded the Papworth Colony near Cambridge in 1918. In 1899 he succeeded A. A. Kanthack as professor of pathology in the University of Cambridge, where he played a leading part in the planning of new laboratories. His best-known books are "Practical Pathology" (1883), for many years the standard text-book for students, and "Pathological Mycology" (1885) with A. W. Hare. Sims Woodhead founded the *Journal of Pathology and Bacteriology*, of which he was the sole editor until 1906, when he continued as editor-in-chief until 1920. For his work on chlorination of water for the supply of troops and for other war services he was created K.B.E. in 1919. He was president of the Royal Microscopical Society and of the Pathological and Bacteriological Laboratory Assistants' Association, which he was instrumental in organizing. A militant teetotaller, a genial companion and a delightful host, Sims Woodhead died on December 29, 1921, after a long period of failing health.

Honorary Fellowships of the Imperial College of Science and Technology, London

THE following have been elected to honorary fellowships of the Imperial College of Science and Technology, London: Dr. Eric Ashby, president and vice-chancellor of The Queen's University, Belfast; Mr. L. C. Hill, technical adviser to the board of the Rio Tinto Company; Sir George Nelson, chairman and managing director of the English Electric Co., Ltd.; Prof. J. A. S. Ritson, emeritus professor of mining in the Imperial College; Sir George Thomson, master of Corpus Christi College, Cambridge, and emeritus professor of physics in the Imperial College.

Pastoral Research at Armidale, New South Wales

A SMALL research committee is being established by the Commonwealth Scientific and Industrial Research Organization, Australia, and by the University of New England, so that pastoral research by the staff at the Armidale Regional Pastoral Laboratory of the C.S.I.R.O. and by the University's newly established Faculty of Rural Science will be closely linked and that the resources of both can be related and used to best advantage. For the time being, the committee will comprise the following: Prof. G. L. McClymont, recently appointed to the chair of rural science at the University of New England, who will act as chairman and University representative; Mr. R. Roe, the senior officer at Armidale of the Division of Plant Industry, C.S.I.R.O., who will be deputy chairman and representative of the Division of Plant Industry; Dr. A. T. Dick, of the Division of Animal Health and Production, Parkville, who has been appointed because of his outstanding knowledge and experience

in the problems of animal and plant relationships; and Mr. J. F. Barrett, of the Armidale Laboratory, who will act as secretary and executive officer of the committee. The chiefs of Divisions of Plant Industry and Animal Health and Production of the C.S.I.R.O. will be *ex officio* members.

Recent Earthquakes

During February and March seven earthquakes occurred having logarithmic magnitude greater than 6. The greatest of these occurred on February 27 in the Kermadec Islands region, and had a magnitude of 8. The next greatest occurred on March 31 near the north-west coast of Mindanao in the Philippine Islands. In this latter shock most destruction appears to have happened in the Lake Lanao region, with Iligan, Dansalan City and Ozamis City the most affected places. In Ozamis City the Catholic church and many port facilities collapsed, and water and electricity systems were seriously damaged. The property damage left some ten thousand people homeless, 425 persons being killed and two thousand injured. On February 18, fourteen persons were killed during an earthquake which caused moderate property damage at Quetta (see *Nature*, February 26, p. 370). A deep-focus earthquake, having a focal depth of 600 km., occurred on February 8 in southern Bolivia, and two on February 23 in the Fiji Islands region. European earthquakes occurred on February 9 at Foggia in southern Italy, on March 18 at Benevento in Italy, on February 17 near the north coast of Sicily and on February 21 near lat. 39° N., long. 23° E. This last caused damage and casualties at Volos in Greece. On March 28 a further earthquake occurred near the south coast of Greece causing damage at Pirgos. On April 11 a second shock occurred at Mindanao, causing further property damage, while on April 19 and 21 further shocks occurred near Volos in Thessaly. On April 19, after a minor tremor, the earthquake caused the collapse of three hundred houses and damage to four-fifths of the buildings in Volos. Only one person was killed and forty-two injured, but more than three thousand were rendered homeless. The second strong shock on April 21 caused the collapse, to the accompaniment of large clouds of dust, of many of the buildings weakened by the first shock, so that now, in a town of some fifty thousand inhabitants, only about a hundred houses remain standing. Government House is so damaged that it is uninhabitable. In this second earthquake near Volos within forty-eight hours, six or more persons were killed and more than sixty seriously injured.

Sandwich Training and Education

The case for 'sandwich' courses consisting of full-time work in industry alternating with full-time study in senior educational institutions was discussed at a meeting arranged by the Southern Regional Council for Further Education at Southampton in October 1954. The chief advocates were Sir Arthur Smout and J. Wilson, principal of the Birmingham College of Technology. Sir Arthur argued that these courses are particularly valuable for young men who have just failed to comply with a certain standard imposed as a condition of matriculation—the 'near pass' man. Through sandwich systems of training, these men might well develop into promising technologists instead of becoming technicians. To make sandwich courses effective, he said, industrialists must get away from the idea that all higher education must be of the university type, governed by university standards and inspired by university ideals.

In his address, Principal Wilson stated that sandwich training and education courses are mainly the concern of the technical colleges. Their objectives should be to achieve a technological standard not less than, and probably higher than, that connoted by the Higher National Certificate; to give a broad knowledge of the fundamental sciences on which a particular technology is based; to relate studies in which a student-apprentice is primarily engaged to those other branches of technology in order to avoid narrow specialization; to integrate theoretical studies with practical training, particularly during the last year of the course; to give some understanding of the historical and economic basis of society in relation to industry; and to develop powers of expression and social competence necessary for a person to play an effective part in an industrial organization.

Marshall Aid Commemoration Commission: Report for 1954

Under the Marshall Aid Commemoration Act, 1953, a Marshall Aid Commemoration Commission was appointed by the Secretary of State for Foreign Affairs, with Sir Oliver Franks as chairman, and the first annual report, covering the year ended September 30, 1954, has now been issued (Cmd. 940. London: H.M.S.O., 1955; 3*d*. net). The Commission, which includes among its members Lord Adrian and Lord Baillieu, with Sir Charles Morris and Sir Philip Morris *ex officio* as, respectively, chairman of the Committee of Vice-Chancellors and Principals and vice-chairman of the Association of Universities of the British Commonwealth, was in operation for only part of the year, and its two meetings were concerned largely with planning for the first group of twelve Marshall scholars to take up their studies in Britain in October 1954. Of these twelve, one is studying political science, another industrial relations and a third anthropology, at the London School of Economics and Political Science; a fourth is studying the physics of metals at the University of Bristol, and the remainder are reading history, law, classics, literature, economics or oriental studies. Some minor amendments have been made to the regulations for the next elections of Marshall scholars, providing a more precise definition of the age-limit for candidates, for payment of candidates' travelling expenses to interviews, for rejection of incomplete applications, the inclusion of employment as qualification for application in a particular region and for clarification of the position about holding another award. No accounts are presented, as the expenditure of £1,877 for the year ended March 31, 1954, was borne by the Foreign Office. Expenditure for 1954–55 is estimated at £9,312.

Chemical Branch of the London County Council

The report for 1953 of the London County Council Medical Officer of Health and Principal School Medical Officer contained an account of the Chemical Branch, including a history of the Branch since its formation, prepared by Mr. C. J. Regan, who retired from the position of chemist-in-chief in March 1954; and this latter report has now been reprinted under the title "The Application of Chemistry and Allied Sciences to the Public Service". A consulting chemist was first appointed to the Metropolitan Board of

Works in 1869, and in 1878 this became a full-time appointment, when a Chemical and Gas Department was formed. In 1889, after the constitution of the London County Council, the Council took over the functions of the Board of Works, the duties of which were then largely concerned with sewage disposal and gas supplies. When treatment of sewage by chemicals was introduced, this became a joint service between the chief engineer and the chemist. Other chemical work carried out at the formation of the London County Council dealt with the examination of general stores such as soaps, oils, etc., and of foodstuffs for residential institutions, and statutory work on the testing of petroleum in relation to the issue of storage licences.

In 1912 the Chemical and Gas Department was abolished, and the bulk of its work was merged in the then rapidly developing Public Health Department, of which it became the Chemical Branch. Mr. Regan reviews the way in which the work of the Branch has grown in complexity with the advance of scientific knowledge and also emphasizes the economic value of its work, for example, in the preparation of approved lists of paints and checking the qualities of deliveries of paint, which have reduced to an exceedingly low level failures among paint, an item on which more than a million pounds a year is spent. More than twenty-five thousand samples were examined in 1953, the most numerous categories being samples of river water, sewage and effluent, primary and digested sludge, water from steam-raising plant, clay, sub-soils and borehole waters, and paints, varnishes and distempers. The staff of fifty-four includes twenty-seven professionally qualified chemists; the report abounds in examples of the way in which the work of the Branch safeguards public health and welfare.

Nutrition of the Rubber Tree

A RECENT issue of the scientific journal of the Rubber Research Institute of Malaya contains two contributions on the nutrition of the rubber tree. E. W. Bolle-Jones (*J. Rubb. Res. Inst. Malaya*, **14**, 231; 1954), using seedlings of a particular clone of *Hevea brasiliensis* grown in pot sand culture, has investigated the inter-relationships of magnesium, potassium and phosphorus on growth. A close inter-relationship between the three nutrients, affecting the growth and composition of the plant, was demonstrated. It was found that the concentrations of rubber in the stems and petioles varied slightly with nutrient-levels, and that they were inversely related to the dry-weight values. The same author, with K. Ratnasingam (*ibid.*, 257), has also investigated inter-clonal and seasonal variations in the composition of leaves. By appropriate sampling and analysis of three clones, they have found that the petiolar rubber concentration and the laminar concentrations of chlorophyll, ash, nitrogen, phosphorus, magnesium, potassium, calcium and iron varied according to the clone. With increasing age of leaf there were increases in the petiolar concentration of rubber and the laminar concentrations of chlorophyll, ash, calcium, iron and manganese, but decreases in the laminar concentrations of nitrogen, phosphorus and potassium. The month of sampling had an important effect on the concentration of each variable examined. It also had a significant influence on the effect of whorl position (or age of leaf) on the concentrations of rubber, chlorophyll, phosphorus and calcium found. Different clones showed different effects in relation to month of sampling. Seasonal variations in the rubber, nitrogen and iron concentrations could be attributed in part to rainfall distribution. It was also ascertained that the concentration of rubber in the petiole varied according to the nitrogen concentration in the blade, and that this in turn was influenced by the calcium concentration.

Status of Invertebrate Palæontology: 1953 Toronto Conference

THE fourteen papers on "The Status of Invertebrate Paleontology" presented at a symposium in Toronto in 1953 have been published in the *Bulletin of the Museum of Comparative Zoology at Harvard College* (**112**, No. 3, 91; 1954. 2.50 dollars). The authors are American, British and German members of an international team working to produce a "Treatise of Invertebrate Paleontology" under the editorship of R. C. Moore, of Kansas. (Since the symposium was held, two parts of this "Treatise", obtainable from the Geological Society of America at 3 dollars each, have been published: Part *D*, Protista 3, Protozoa (chiefly Radiolaria and Tintinnina), by A. S. Campbell and R. C. Moore; and Part *G*, Bryozoa, by R. S. Bassler.) Following two short introductory articles are nine contributions, each intended for non-specialists, to assess the present state of knowledge concerning classification, patterns of evolution and geological history of a particular group.

Such authoritative accounts are welcome to biologists in both ancient and modern fields. The non-specialist level, inevitably, is placed differently from group to group, and sometimes a bibliography is offered and sometimes not. Familiar groupings now held to be of polyphyletic origin are discarded or their demise is threatened; healthy doubt and ignorance prevail concerning some phylogenies, and in one major group no classification is visualized at present above the superfamily category. The groups treated are: Protozoa by H. E. Thalman; Coelenterata by J. W. Wells; Pelmatozoa by R. C. Moore; Eleutherozoa by J. W. Durham; Pelecypoda by N. D. Newell; Gastropoda by J. B. Knight, R. L. Batten and E. L. Yochelson; Cephalopoda by B. Kummel; Trilobita by H. B. Whittington; and Graptolithina by O. M. B. Bulman. A. Petrunkevitch's essay entitled "Macroevolution and the Problem of Missing Links" offers an explanation why speciation alone fails to account for apparent evolutionary discontinuity. The remaining articles are concerned respectively with the ammonoid suture (O. H. Schindewolf), with the evolution of late Palæozoic invertebrates in response to major oscillations of shallow seas (R. C. Moore) and with various aspects of skeletal materials (H. A. Lowenstam). This stimulating publication has been edited by B. Kummel, who was the chairman of the symposium.

Extraction of Small Fragile Ammonites

IN the February issue of the *Museums Journal*, Mr. C. P. Watkins outlines an inexpensive method for hardening, extracting and developing the surface detail of small, thin, fragile ammonites which occur in the Lower Lias shales of Leicestershire. The top cover of matrix is removed and the specimen immersed in industrial alcohol for five minutes. The matrix is smeared with 'Vaseline', and a thin layer of shellac is painted over ammonite and 'Vaseline' and allowed to harden. When the film is removed, the ammonite

generally adheres to it. The under-surfaces of the ammonite and film are cleaned with benzolene and fragments of matrix removed. After drying, the specimen is placed film downwards on a glass sheet smeared with 'Vaseline'. A shellac film is painted on, and at the tacky stage a paper slip with registration number is affixed. When hard, the edges of the shellac are trimmed with a pair of scissors. Surface relief may be increased by treating the shellac surfaces with alcohol.

National Museum of Wales : Report for 1953–54

The annual report for 1953–54 of the National Museum of Wales (pp. 63+4 plates; from the Museum, Cardiff; 1954) appears again in its new format and stresses the most urgent needs which were formulated by the Standing Commission in 1953. These include the erection of the western extension of the Museum and a museum block at the Welsh Folk Museum at St. Fagans. Although the first need remains in abeyance, a start has been made on the new Folk Museum at a cost of approximately £15,000. An "Exhibit of the Month" is now a regular feature. This is arranged in turn by the departments concerned. The Department of Archæology reports a full programme of field-work. At Caerleon, Dr. V. E. Nash-Williams undertook the exploration of a five-acre site outside the Roman legionary fortress. A legionary civil settlement was proved, and datable material suggests that the buildings were in occupation from A.D. 100 to 300 or later. The site was also exceptionally rich in small finds. In addition to carrying out much extra-mural work of a character cognate to their normal museum tasks, the staff are responsible for an impressive list of publications.

Science and the Press

The greater part of the March issue of the *Atomic Scientists Journal* is devoted to a symposium on science and the Press. The symposium included that part of Mr. L. J. F. Brimble's lecture to the Royal Society of Edinburgh in January 1954 which dealt with the interpretation of science; a contribution from Mr. L. Bertin, science correspondent of the *Daily Telegraph*, in which the position of the journalist is explained with clarity and understanding and the qualities demanded of a science writer are indicated; a discussion by Mr. Ritchie Calder of some causes of misunderstanding between scientific workers and journalists; and a summary by Dr. A. V. Cohen of the main points in a set of articles on the relations between scientific workers and the press contributed to the November 1953 issue of the *Bulletin of the Atomic Scientists* (U.S.A.). Mr. Calder's constructive article includes the statement that, in his opinion, a science editor should leave out, as scientifically dubious, scientific news which, for reasons of space, cannot be expounded or qualified, even though it may be *prima facie* of journalistic interest. He also stressed the difference between the presentation of scientific facts and helping people to understand the effects of scientific development. For satisfactory relations between scientific workers and the Press one condition is fundamental: the facts are inalienably the concern of the man of science, but their treatment is the function of the scientific journalist, for which he is trained.

Man's Role in Changing the Face of the Earth

The Wenner-Gren Foundation for Anthropological Research, New York City, with the aid of the National Science Foundation, Washington, D.C., is organizing an international symposium on "Man's Role in Changing the Face of the Earth", to be held during June 16–22 at the Princeton Inn, Princeton, N.J. Participation is limited to eighty invited experts, of whom seventeen are from outside the United States, representing India, Egypt, Israel, France, Belgium, Germany, Great Britain and Canada. The symposium will explore the question: What has been, and is, happening to the earth's surface as a result of man having been on it for a long time, increasing in numbers and skills in an uneven manner, with respect to place and time? The three main factors involved are: the earth's resources; the numerical pressure of population upon, and sustained by, the resources; and man's differing cultures, or ways of life. Fifty-two background papers, each reviewing some particular aspect and outlining the problems for future research, will be presented. Further information can be obtained from the organizer of the symposium, William L. Thomas, jun., Wenner-Gren Foundation, 14 East 71st Street, New York 21.

Cold Spring Harbor Symposium on Population Genetics

The twentieth Cold Spring Harbor Symposium on Quantitative Biology will be held during June 6–13, the subject being "Population Genetics: the Nature and Causes of Genetic Variability in Populations". The object of the Symposium will be to bring leading workers together in an effort to establish an area of agreement on fundamental concepts common to both agricultural genetics and evolutionary genetics, and to this end the discussions will be focused on the following topics: general population genetics theory; theory of quantitative genetics; selection in plants; selection in animals; genetic variability and polymorphism; populations in time and space; and integration of genotypes. The Symposium is open to all who are interested. Further information can be obtained from the Biological Laboratory, Cold Spring Harbor, New York.

University of London

The following appointments have been made in the Imperial College of Science and Technology: Dr. J. McG. Bruckshaw, reader in geophysics in the College, to the University chair of applied geophysics; Prof. D. G. Christopherson, professor of mechanical engineering in the University of Leeds, to the University chair of applied science with special reference to engineering; Dr. Arthur Porter, head of the Research Division of Ferranti Electric, Ltd., Toronto, to the University chair of light electrical engineering.

Other appointments include the following: Dr. William Holmes, assistant in animal husbandry at the Hannah Dairy Research Institute, to the University chair of agriculture tenable at Wye College; Dr. J. G. Powles, I.C.I. Fellow in the University of Durham, to the University readership in experimental physics tenable at Queen Mary College; Dr. G. B. West, lecturer in pharmacology in the University of St. Andrews, to the University readership in pharmacology tenable at the School of Pharmacy.

The Night Sky in May

Full moon occurs on May 6d. 22h. 14m., U.T., and new moon on May 21d. 20h. 58m. The following

conjunctions with the moon take place: May 7d. 06h., Saturn 6° N.; May 20d. 02h., Venus 6° S.; May 23d. 10h., Mercury 2° N.; May 23d. 18h., Mars 1° N.; May 25d. 17h., Jupiter 3° N. In addition to these conjunctions with the moon, Jupiter is in conjunction with Pollux on May 6d. 18h., Jupiter 6·3° S. Mercury sets at 20h. 10m., 21h. 45m. and 21h. 30m. on May 1, 15 and 31, respectively, and owing to its increasing northern declination it is better placed for observation than it was in April; seen in the western sky, its stellar magnitude varies from −1·4 to 1·4 during the month, the visible portion of its illuminated disk decreasing from 0·928 to 0·178 and its distance from the earth decreasing from 117 to 62 million miles. Venus rises at 3h. 50m., 3h. 25m. and 3h. at the beginning, middle and end of the month, respectively, its stellar magnitude varying from −3·4 to −3·3 and the visible portion of its illuminated disk from 0·837 to 0·904; in spite of this increase in the visible portion of the illuminated disk, the stellar magnitude remains nearly the same because its distance from the earth increases from 125 to 140 million miles. Mars sets at 22h. 25m., 22h. 15m. and 22h. on May 1, 15 and 31, respectively; its easterly movement from Taurus into Gemini is easily seen, and towards the end of the month it is fairly close to the stars μ and η Geminorum. Jupiter is visible until late in the night, its times of setting being 1h. 05m., 0h. 20m. and 23h. 20m. at the beginning, middle and end of the month, respectively; its eastward movement from south of x Geminorum into the constellation Cancer is easily observed, but the small decrease in brightness, from magnitude −1·6 to −1·5, owing to an increase of nearly 40 million miles in its distance from the earth, is not obvious to the naked eye. Saturn is in opposition on May 9 and sets in the early morning hours at 5h. 15m., 4h. 15m. and 3h. 10m. on May 1, 15 and 31, respectively. It has a slow movement towards Librae, its stellar magnitude varying between 0·3 and 0·4 owing to its distance from the earth increasing from 828 to 833 million miles. The star 55 Leo. is occulted on May 1d. 22h. 03·9m., the only occultation of stars brighter than magnitude 6 during the month. The Aquarid meteors are active during May 1–6, but moonlight may make their observation difficult during part of the time.

Announcements

THE Paris Academy of Sciences has elected Prof. Jean Timmermans, professor of physical chemistry in the University of Brussels, and Prof. Arne Tiselius, professor of chemistry in the University of Uppsala, to be *correspondants* for the Sections of Free Academicians and of the Application of Science to Industry in succession to the late Prof. E. Hubble, and Prof. M. Siegbahn, recently elected a foreign associate of the Academy.

WE regret to announce the following deaths:

Major F. B. Halford, C.B.E., chairman and technical director of the de Havilland Engine Co., Ltd., president during 1951–52 of the Royal Aeronautical Society, on April 16, aged sixty-one.

Dr. H. R. Raikes, principal and vice-chancellor of the University of the Witwatersrand until 1954, on April 13, aged sixty-three (see also *Nature*, **173**, 17; 1954).

IN a Parliamentary written reply, it is announced that the following committee has been appointed to review the organization of the Meteorological Office in relation to current and future requirements: Lord Brabazon of Tara (chairman), Sir Charles Darwin, Major R. H. Thornton, Sir Folliott Sandford and Mr. J. R. Simpson.

THE Road Research Laboratory of the Department of Scientific and Industrial Research is holding two open days during May 12–13 (10 a.m.–5 p.m.), when both the Materials and Construction Division at Harmondsworth and the Road Safety Division at Langley will be exhibiting their latest research work and giving practical demonstrations. Application to visit the Laboratory on either of these two days should be made to the Director of Road Research, Road Research Laboratory, Bath Road, Harmondsworth, Middlesex.

THE Society for Applied Bacteriology will hold its summer conference and annual meeting in Cambridge during July 4–6. The first two days will be devoted to a symposium on food microbiology and public health, at which sixteen papers will be read, six by workers from overseas countries. The subjects to be dealt with at the symposium will be synthetic cream, etc., fruits and vegetables, fish, fresh meat, processed meat, and bacteria causing food poisoning. Further information can be obtained from the honorary secretary, G. Sykes, Microbiology Division, Boots Pure Drug Co., Ltd., Nottingham.

THE tenth specialized course for physicists and electronic engineers on the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry and in work with radioisotopes will be held in the Isotope School, Atomic Energy Research Establishment, during May 23–26. Attendance at the course, which will be entirely non-secret, is limited to twelve. The fee is 12 guineas, and accommodation can be arranged locally at a charge of 4 guineas approximately. Application forms, to be returned by May 6, can be obtained from the D.A.O., Electronics Division, A.E.R.E., Harwell, Didcot, Berks.

A SUMMER school in theoretical chemistry for university and college teachers of chemistry and chemical research workers in industry will be held in the University of Oxford during September 10–24 under the direction of Prof. C. A. Coulson, with Prof. M. J. S. Dewar (London) and Prof. H. C. Longuet-Higgins (Cambridge) as lecturers. Three courses of lectures will be given on the general principles and theory of valence; the structure and properties of π-electron systems; and chemical reactivity. In addition, there will be a number of discussions and also opportunities to make calculations using desk calculating machines. The fee for the whole course, which is residential, is £32. Application must be made before June 15, application forms and further information being obtainable from the Secretary, Oxford University Delegacy for Extra-Mural Studies, Rewley House, Wellington Square, Oxford.

THE Royal Society of Edinburgh is offering a David Anderson-Berry Silver-gilt Medal, together with about £100, for work on the therapeutical effect of X-rays on human diseases. Applications for the Prize should be accompanied by details of both published and unpublished work. Applications must be sent by March 31, 1956, to the General Secretary, Royal Society of Edinburgh, 22–24 George Street, Edinburgh 2.

BRITISH SOCIETY OF ANIMAL PRODUCTION, 1944–54

FOR many years before the Second World War it had become recognized by scientific workers and practical animal husbandmen that the marginal territory over which both groups move could not be reasonably developed unless means were found of exchanging ideas and experience and of combining them in a scientific approach to problems of animal production. The position in Great Britain differed sufficiently from those in other countries to limit adoption here of precisely the same patterns of organization for this purpose as had been set up overseas; the livestock industries were under less direct governmental and administrative control than in parts of Europe, where bodies with similar aims were in being or contemplated; in the United States the American Society of Animal Production was well established, with a large membership, mainly of scientific workers and advisers, and a long record of valuable published contributions; and, moreover, university departments and research institutes in Great Britain were not so specialized or so opulent, and yet the art and practice of stock husbandry was traditionally on a high plane of achievement.

Again, research workers were more and more tending to present their findings in journals and at meetings so specialized that they were relatively inaccessible to the practical man. Almost as an immediate result of this sectionalization of interests, it was increasingly more difficult for specialists in cognate fields to come together to discuss the mutual inter-relationships of their work, and even more so for the practical stockman to meet the scientist on common ground.

In 1939 the time appeared ripe to form a British organization which might meet local needs and ultimately link up with the European Association then being instituted to foster the wider interests of the existing national societies; and a small group, led by Dr. John Hammond, began to consult with breeders, research workers and advisory officers with this objective. The outbreak of the War imposed delay; but the informal group kept together and by the end of 1943 judged that their ideas could be made more widely known. It was realized that no large membership could be expected for some time, but the response was immediate and enthusiastic. The first meeting was held early in 1944, a constitution adopted, and with Dr. Hammond as its first president, the new British Society of Animal Production began to develop four broad ways of policy.

The first related to reviews of the main sections of the livestock industry, and was in a sense introductory or short-term. By 1944 not only had British animal production been greatly disturbed, with the main emphasis on milk, but also it was clear that difficult problems would appear in any post-war period of readjustment. It is interesting to note from the reports of those earlier meetings, at which the sheep, meat and pig situations were examined, how well the position which was to arise in the late 1940's and these early 1950's was then foreshadowed. That this could be so was largely due to the course taken towards the second line of policy: the founders aimed at securing roughly equal proportions of membership from the scientific, the advisory and the practical fields. It is noteworthy that such a balance in the roll of members still exists and that each field contributes freely and effectively to the business and vigour of the Society.

A third line of policy was to hold, if possible, two meetings a year: one in London to receive formal papers and discussion; and the second in the Provinces, primarily to provide opportunities of visiting research centres, to view practical developments in animal husbandry, and to consider, on the ground, the livestock industries of the area. This mode of operation still continues, enabling the basic aims of the Society to be firmly expressed. The fourth line of policy was to publish records of the proceedings of the Society in the hope that ultimately the depth and breadth of the volume of progress in the field of scientific animal production in Great Britain would sustain the quality of contributions to a substantial journal. The publication of the "Proceedings" of the Society for 1954 gives an opportunity for reviewing progress made by the Society in the first ten years of its life*.

From the earlier form of reports of meetings, with their records of discussions on the formal papers presented, and accounts of local stock industries and husbandry methods, the first outward development was made in the "Proceedings" for 1952. In that year the serious outbreak of foot-and-mouth disease eliminated the autumn 'local' meeting, so that with no report on it to publish, space was given to an account of the activities of the European Association for Animal Production (to which the Society had attained working membership) and, more significantly in relation to policy, to two contributions on progeny testing—the first being a valuable review of principles and methods by Johansson and Robertson, and the second a critical assessment by Mason of the system and results of bull-progeny testing in Denmark. These papers not only formed an introduction to the central theme of the eighteenth meeting held in 1953, but also added materially to the status of the Society's publications as an essential source of reference to work in the general field.

The 1953 "Proceedings" record a symposium on progeny testing in dairy cattle, pigs, sheep and poultry, together with three special papers on then current research in Scotland, involving feeding experiments with twin cattle, pig research at the Rowett Research Institute, and work by K. L. Blaxter on the relationships of diet to muscular disease in calves.

The next step in policy was taken in 1954 when, at the spring meeting, sixteen papers were given as accounts of work in progress. Compared with the offerings in previous "Proceedings", they form not an orderly sequence of courses but a mixed dish the components of which vary greatly in substance, digestibility and net value, yet which as a whole is appetizing and satisfying as representative of the products becoming available from the further scientific exploration of animal production in Great Britain. Some contributions are given in full, and others only by summary. They range from studies on techniques of weighing grazing animals and the results of winter grazing methods, to comparisons of

* Proceedings of the British Society of Animal Production, 1954. Pp. 116. (Dalkeith: Scottish County Press, 1954.) 15s.

breeds and crosses for beef production; from examination of the seasonal changes in management in relation to milk yields to the assessment of progeny test results and to the effects of inbreeding on performance in dairy cattle; from investigations on nutritional levels in late pregnancy, through others on meat quality and on body size in reciprocal crosses, to analyses of the factors of flock size and flock duration in the population genetics of sheep. There are also reports of work on the use of partial records in poultry selection, on the experimental shortening of the generation interval in rabbits by gonadotrophin treatment, and preliminary accounts of comparisons of different sources of vitamins A and D in relation to the fattening of pigs and of X-ray studies on the structure and variation of the vertebral column in the Welsh breed of pigs.

The "Proceedings" are well edited, and appear in pleasing and convenient format: their diffuse contents may suggest that in this step of policy the riser is too high too early in the stairway to the platform of a British Journal of Animal Production. On the other hand, the tread seems sound, and it may well be that the Society can now move up and on to achieve this particular aim, without side-tracking its other aims, of which the study of local methods and practices of animal production is by no means the least valuable and of which all record has been somewhat regrettably omitted for 1953 and 1954.

J. E. Nichols

BERLIN ACADEMY OF SCIENCES

THE first 'annual meeting' of the Deutsche Academie der Wissenschaften zu Berlin to be held since the War took place during March 28–April 2. Until 1939, there had been an annual celebration of the first president of the Academy, G. W. Leibniz. The present meeting was a revival of this tradition. Some four hundred and seventy scientists from Eastern Germany and some eighty scientists from other countries, including Western Germany, took part in the meetings.

The opening session was held in the Grosser Festsaal im Haus der Ministerien and was addressed by the president of the Academy, Prof. W. Friedrich, well known as the co-discoverer, with von Laue and Knipping, of the diffraction of X-rays by crystals. Government representatives present included the president of the Volkskammer, Dr. Dieckmann, and the Prime Minister, Otto Grotewohl. After Dr. Friedrich had spoken, each of the secretaries of the five sections of the Academy reported on his own section. Last year a considerable reorganization of the Academy took place so that the subjects are re-grouped in the following way: (1) mathematics, physics, engineering; (2) chemistry, geology, biology; (3) medicine; (4) language, literature and art; (5) philosophy, history, law, economics. (The inclusion of non-natural science subjects within the purview of the Academy follows a common Continental custom of using the word science in the meaning of 'scientas'.) The secretaries' reports all showed a very considerable development of the work done by the various institutions and laid stress on the need for ensuring a proper application to industry of the results of scientific research. The present secretaries of the sections are, respectively, Profs. Rompe, Noack, Lohmann, Frings and Unverzagt. The second full session was addressed by Prof. Kurt Mothes on "The Roots of Plants—a Chemical Factory of a Particular Kind", and by Prof. Wolfgang Steinitz, vice-president of the Academy, on "Songs and Fables as Expressions of the Spirit of a People". Then followed two and a half days of conferences on specialized subjects. These included "Physics and Chemistry of Crystals", "Metallurgy of Iron", "Radio-astronomy", "Fibres from Synthetic High Polymers", "Results and Problems of Biochemical Research", "Questions concerning Cancer Research and Treatment", "Dialect Study", "Songs, Fables, Proverbs and Sayings, as expressions of the Spirit of a People". There were also lectures by Prof. Gordon Childe (London) and Prof. Hans Jürgen Eggers (Hamburg) in the Institute for Pre- and Early-History, and by Prof. Johannes Straub (Bonn) in the Commission for Spätantike Religionsgeschichte. Visits were arranged for all the visitors to the laboratories and institutions in which they were interested. An informal reception was arranged on the first evening and a dinner party in the great hall in the Haus der Ministerien at the conclusion of the meetings. A two-day excursion to Weimar, famous for its associations with poets, was arranged for those who had time to go.

Certain general impressions may be worth recording. The scientific institutions and those who work in them are flourishing; the material means both in terms of research facilities and salaries are good. There is a widespread desire for more contact with scientists in other countries, and a wish to be able to attend international conferences more easily than is possible at present. The publications of the Akademie Verlag include a considerable number of translations of important modern Soviet books, and for those who cannot read Russian the German Academy is likely to be of great service through those translations. Finally, it should be said that the friendliness and hospitality shown by our hosts were all that could be desired.

W. A. Wooster

NATIONAL SCIENCE FOUNDATION, WASHINGTON, D.C.

REPORT FOR 1953–54

THE fourth annual report* of the National Science Foundation, Washington, D.C., covers the year ended June 30, 1954, and includes, besides the report of the director, Dr. A. T. Waterman, a foreword by Chester J. Barnard, chairman of the National Science Board, and appendixes listing the personnel of the Board and its advisory panels and committees and the basic research grants made during the year, as well as a complete list of individuals awarded fellowships in 1954. Mr. Barnard emphasizes in his foreword that the central task of the Foundation is the promotion or cultivation of science in the United States, and in this connexion notes the importance of incentives for the pursuit of scientific careers. A deep, personal and indefatigable interest in scientific discovery is the primary and indispensable incentive; but relative freedom, adequate remuneration and public esteem are also important, and lavish and indiscriminate expenditure will not counterbalance conditions which discourage initiative, imagination

* National Science Foundation. Fourth Annual Report for the Fiscal Year ending June 30, 1954. Pp. ix+138+4 plates. (Washington, D.C.: Government Printing Office, 1954.) 50 cents.

and persistence. Wisely administered programmes of scholarships and fellowships are invaluable for encouraging the development of scientific workers, and this, as well as the acquisition of scientific knowledge, are the main purposes for the Foundation's support of research.

During the year ended June 30, 1954, the Foundation made 374 grants, totalling 3,888,220 dollars, for the support of basic research in the natural sciences, compared with 269 grants, totalling 2,751,912 dollars, in the previous two years. Of these, 177 (totalling 1,929,470 dollars) were in the biological and medical sciences and 197 in the mathematical, physical and engineering sciences, and during the past year the Foundation has assumed the primary responsibility for Federal support of basic research in radio-astronomy, pure mathematics, low-temperature research, systematic biology and ecology. Special attention is directed to the Foundation's support of work on the utilization of high-temperature energy and low-level or solar energy, on meson physics, Hilbert space, luminescence, steroid chemistry, archæology, and on the history, philosophy and sociology of science. In March 1954 the Foundation announced the award of 657 fellowships and 79 post-doctorate fellowships for advanced study in the natural sciences for the year 1954–55. Of these, 213 were in the biological sciences, 171 in chemistry, 92 in engineering, 33 in the terrestrial sciences, 72 in mathematics and 155 in physics and astronomy. The programme of regional summer institutes and conferences for science teachers was extended, and four such conferences were held; conferences on solid-state physics in engineering education and on nuclear physics in engineering education were also arranged to assist the inclusion of some of the more recent advances of science into the engineering curriculum, while the Foundation also sponsored an experimental summer conference for high-school mathematics teachers.

During the year the American Institute of Physics, at the request of the Foundation, initiated an inquiry to determine the desirable limits of a plan for improving the coverage, abstracting and translation of important current reports on physics research in the Soviet Union. Areas in which complete English translations of Soviet physics journals are particularly desirable are molecular spectroscopy, magnetism, low-temperature physics, underwater sound and related applied acoustics, solid-state physics, non-linear mechanics and differential equations. The Foundation continues to support the American Mathematical Society's programme of translating Russian mathematical papers and, with the Atomic Energy Commission, to sponsor the collection and listing, by the Scientific Translation Centre of the Library of Congress, of scientific translations from periodicals of the U.S.S.R. The Foundation has also now established the criteria to be used for evaluating requests for financial assistance to scientific publications, and during the year travel grants were approved to 101 American scientific workers to enable them to participate in some twenty-five international scientific meetings.

A special feature of the work of the National Science Foundation is its sponsoring of conferences in special areas of science. In this way the Foundation is able to encourage research in fields of potential national interest but for which industrial support is not available. Jointly with one or more private or public agencies, including the universities and scientific societies, the Foundation supported nine teen such conferences during the year. They included those at Lowell Observatory on photoelectric problems, techniques and instrumentation for astronomical research; at Northwestern University, Evanston, on the present status of position measurements of celestial bodies; with the University of Wisconsin on the utilization of solar energy; with the University of Chicago on nuclear processes in geological settings; and with the Columbia University on the role of proteins in the transport of ions across membranes. A symposium on glutathione research was sponsored jointly with Columbia University and the Office of Naval Research, and an international conference on cosmic ray research with Duke University, while the Foundation also joined with the Rice Institute, Houston, Texas, and the International Union of Pure and Applied Physics in sponsoring the Third International Conference on Low Temperature Physics and Chemistry. In co-operation with the American Academy of Arts and Sciences, the Institute for the Unity of Science and the American Association for the Advancement of Science, the Foundation supported a conference on the validation of scientific theories; one on radio-astronomy, with the Carnegie Institution of Washington and the California Institute of Technology; on high-speed computing in meteorology and oceanography, with the University of California; on multi-dimensional analysis in psychological research, with the University of Michigan; and on present-day theories of liquids and the use of acoustical methods in studying the structure of liquids, with Brown University. The Foundation also sponsored a conference on the luminescence of biological systems and symposia on physiological development of the mammalian fœtus, with the Long Island Biological Association; on development and growth, with the National Institutes of Health, the Society for the Study of Development and Growth, and Dartmouth College; as well as conferences on problems in human communication (with the Massachusetts Institute of Technology) and, with Cornell University, on fundamental problems of perception.

Details are also given in the report of the proposed United States programme for the International Geophysical Year in 1957–58, in which the Foundation is responsible for co-ordinating the Federal interests and handling the fiscal and administrative planning for the United States Government. For the rest, the director's report makes it plain that the preoccupations of the Foundation are similar to those of the Advisory Council for Scientific Policy or the Lord President of the Council in Great Britain. The importance of a clear understanding of what science is about, particularly in view of a Federal expenditure on research and development of more than two thousand million dollars, more than 90 per cent of which is for applied research and development, is emphasized. There is concern over the effect of technological and military secrecy on scientific work and the recruitment of scientists; in the United States, as in Great Britain, there is concern over the output of scientific workers, as well as their utilization, and over a shortage of science teachers, and there is no evidence that the loss of science doctorates, estimated at nine thousand during 1942–49, will be made up. Concern is expressed also over the extent to which physics research is pursued in colleges, and the Foundation is making a series of studies of research at educational and other non-profit institu-

tions; the research programmes of Federal and State Governments; surveys of research at non-profit institutes and by commercial laboratories, by trade associations and similar organizations; and industrial research and development in general.

NATURAL PERMANENT MAGNETIZATION OF THE LOWER BASALTS OF NORTHERN IRELAND

A PAPER by J. Hospers and H. A. K. Charlesworth (*Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **7**, 1; October 1954) gives the results of investigations on the natural permanent magnetization of the so-called Lower Basalts of Northern Ireland. It has been known for at least a hundred and fifty years that eruptive rocks have a permanent magnetization which is much larger than can be acquired in the present geomagnetic field at 20° C. Moreover, evidence from various sources confirms the view that the natural direction of magnetization of an igneous rock is the same as that of the local geomagnetic field at the time of its solidification, allowance being made for subsequent tectonic movements. Hospers has recently published the results of his investigations of the history of the geomagnetic field in Iceland from Miocene times to the present day—that is, during the past twenty million years—and has shown that the natural permanent magnetization of the Icelandic lava flows originated when these flows cooled down after their extrusion. A similar investigation was undertaken in Northern Ireland, and in the paper under review Hospers and Charlesworth show by means of a diagram the extent of the Tertiary plateau basalts and the localities where samples were taken.

The cylindrical specimens of known orientation, a hundred and twenty altogether, were measured on a simple astatic magnetometer, the technique of which was described by J. Hospers in "Palæomagnetic Studies of Icelandic Rocks" (Ph.D. thesis, University of Cambridge, 1953). Corrections to the resulting directions were afterwards applied for the geological dip of the strata, and the final directions were thus obtained, expressed in declination relative to geographic north and in inclination relative to the horizontal plane, both at the point where the samples were taken. The uncertainty in the final directions is discussed under two headings—uncertainty in the declination and uncertainty in the direction in space—and as a result of this discussion it appears that the maximum possible angle between different samples from the same flow consistent with homogeneous magnetization of the sampled part amounts to approximately 20°; as the angle between the directions of samples from flow *C6* (Evish, ¾ mile east of Milltown, Co. Antrim) are smaller than this, the magnetization is almost certainly homogeneous.

A reverse magnetization in all lava flows that have been studied has received a considerable amount of attention in recent years, and various explanations have been offered for it. One is that it is due to the physical properties of aggregates of ferromagnetic minerals which produce reverse magnetization on cooling in a field which had essentially the same direction as the present field, while other explanations invoke reversals of the local or the main geomagnetic field. In analogy with the results obtained by Hospers from his study of Icelandic plateau basalts (published in *Proc. Kon. Ned. Ak. Wet.*, **56**, 467, 477 (1953); **57**, 112 (1954)), there are strong reasons for assuming that the permanent magnetization of the Northern Ireland plateau basalts originated when these flows cooled down for the first time after their extrusion, and also that the direction of magnetization has been stable since that time. There is a short discussion of the 'polar wandering' hypothesis against which there are various arguments; but it is admitted that some of these lose their force if the Lower Basalts of Northern Ireland are much younger than Eocene times, and some authorities believe that they may be Late Miocene and Early Pliocene. The matter is still open to considerable doubt.

TIME-SCALE OF THE UNIVERSE

DR. E. J. ÖPIK, of Armagh Observatory, has greatly expanded and supplemented his essay on "The Age of the Universe", which he originally submitted for the competition on this subject arranged by the Philosophy of Science Group of the British Society for the History of Science and which was published by the Society (*Brit. J. Phil. Sci.*, **5**, No. 19; November 1954; see also *Nature*, **175**, 68; 1955). The new article, which is published in the *Irish Astronomical Journal* (**3**, No. 4; December 1954), provides a very full account of various changes in cosmologists' conceptions of the age of the universe.

The long time-scale—a multiple of a million million years—was largely due to Jeans's investigations into the statistics of stellar motions and also the distribution of the orbits of double stars. The fallacies in his original assumptions are pointed out; in addition, while Jeans carefully considered the effects of encounters on close binaries, he ignored the effects on wide pairs and star clusters. Yet, on his own theory, the effects on the latter should have been thousands of times stronger than the effects on the former. Overwhelming evidence against statistical 'gas-kinetic' equilibrium was a serious blow to the long time-scale, and the fundamental fact requiring a short time-scale—the red-shift of the extragalactic nebulæ—"was like a bombshell amidst the complacent 'permanentists' ".

The misleading evidence derived from radioactive determinations of the age of meteorites and from investigations in other directions is carefully dealt with in the paper. Some recent views are considered, as, for example, that of continuous creation, the acceptance of which would dispense with a finite age for the universe. Öpik dismisses them rather summarily with the remark ". . . these theories can at present be assessed only from the standpoint of their æsthetic value. It is not easy to imagine observational criteria for them which cannot be explained away". His conclusion is that the combined evidence from a number of more-or-less independent sources leads to the view that the age of the universe in its present form and content does not exceed 6,000 million years. The extragalactic nebulæ and also our galaxy, with its backbone of Population ii stars, may have been formed about 4,500 million years ago; the sun as a star of Population i may have come into existence later.

Öpik conjectures that what we now see may be only the metagalaxy—merely a step in the hierarchy of physical systems—and that the observed expansion may refer only to this limited, although large, material system; conditions may be different in other parts of the universe. In the case of closed space, the universe (either the whole or the observable metagalaxy) must inevitably return to the initial state of nuclear fluid, and the universe would oscillate without external loss, "implying an unlimited age in the past and in the future". While some have expressed disgust at the idea of an oscillating universe, Öpik cannot see why it should claim a less æsthetic value than the annual succession of seasons, so praised by poet and layman.

EFFECT OF INCLUSIONS ON STEEL

THAT the mechanical properties of test pieces of steel cut transversely to the direction of working are inferior to those cut longitudinally has been recognized for very many years. Further, it is implicit in many specifications that the process by which a steel has been manufactured exerts its influence on the properties. It is well recognized that the inclusions present play a substantial part in determining the difference of properties in the transverse and longitudinal directions; but it may be doubted whether the mere presence of such inclusions could of itself offer an adequate explanation of all the facts. Why the steelmaking process should have an influence is still a matter largely of speculation, though the gases present—oxygen, hydrogen and nitrogen—and their amounts have been suggested as playing a predominating part.

The Iron and Steel Institute, in Special Report No. 50, has published a paper by Mr. P. H. Frith, on "Fatigue Tests on Rolled Alloy Steels made in Electric and Open-Hearth Furnaces"*, which forms a report of the Fatigue and Inclusions Committee of the British Iron and Steel Research Association. A part of this work was carried out under the auspices of the Inclusions Sub-Committee of the Iron and Steel Institute, formed in 1936, at the instigation of the late Dr. W. H. Hatfield, to investigate the practicability of measuring the standard of cleanliness of aircraft steels by means of some numerical count. It was soon apparent that the grading of steels by this inclusion count method did not necessarily coincide with that based on mechanical properties, and an extensive programme of fatigue tests has been carried out, mainly by the Bristol Aeroplane Co., Ltd. An enormous amount of work has been put into this investigation, which, in some directions, is one of the most important contributions to our knowledge of the factors determining the properties of steel for very many years.

The steels examined were heat-treated to give tensile strengths of 60–110 tons/sq. in. Up to the former strength, the inclusions of the size and type normally present do not appear to exert any particularly detrimental effect, though accidental inclusions of more massive form are probably harmful. As the strength of a steel is increased, however, the effects of the inclusions grow progressively more serious, particularly in reducing the resistance to fatigue. One of the most outstandingly important observations made during the course of this work seems to be the profound influence exerted by the shape and deformability of the inclusions, which therefore are divided into three groups: (1) those which deform during hot-working and become elongated; (2) those which do not deform; and (3) those undeformed inclusions of Group 2 which have a deformable envelope of manganese sulphide.

From the point of view of the stress concentration which results, it is believed that the undeformable inclusions of Group 2 are those which are most detrimental to the fatigue properties. These include hard angular fragments of alumina or alumino-silicates, titanium cyano-nitride, quartz and spherical silicates. It also appears from these tests that, in any event up to 0·04 per cent sulphur, the fatigue properties are not affected by the number of manganese sulphide inclusions so long as this sulphide does not form part of a duplex aggregate. This emphasis on the importance of the plastic properties of the inclusions is supported by the fact that the reduction in the fatigue limit in the transverse direction cannot be directly correlated with the sulphur, oxygen or phosphorus content of the steel, either singly or combined.

In addition to the normal metallographic examination, microradiographs, magnetic tests, etc., were also employed, the importance of the first of these lying in the fact that, although the surface inclusions appear to play no particularly harmful part, there is good evidence that inclusions lying just below the surface, for some reason or other, may, and apparently often do, act as the starting-point for fatigue cracks. In certain steels, particularly basic electric, inclusions of an apparent diamond shape are not uncommon. Careful investigation has shown that the actual inclusion in such cases is itself more or less spherical, but that during the working operation 'cavities' are formed in front and behind, and these apparently may play a profound part in initiating fatigue. It would appear, therefore, that we have here at any rate a partial explanation of the influence of the steelmaking process employed, since open-hearth steels appear to be less prone to contain these hard spherical inclusions than is that made by the basic electric process.

The author has spent many years on this work, and he and the Bristol Aeroplane Co., Ltd., deserve most sincere thanks for the light which is thrown on a problem of the greatest importance to all those who make and who use the higher-tensile steels.

F. C. Thompson

* Iron and Steel Institute Special Report No. 50: Fatigue Tests on Rolled Alloy Steels made in Electric and Open-Hearth Furnaces. By P. H. Frith. Pp. vii+130+22 plates. (London: Iron and Steel Institute, 1954.) 25s., or 15s. to members of the Institute.

STANDARDIZATION OF WOUND TEXTILES

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AS a preliminary to any discussion on the standardization of wound textiles, a brief discussion is necessary as to whether wound textiles are, in fact, true healing agents. My own work has shown that suppuration and œdema of the surrounding tissue results when a wound is covered by a 'Plexiglass' capsule (Baron) (see Figs. 1*a* and 1*b*: the wound rises into the hollow space of the capsule). The effect is

similar to 'window' œdema which often results when openings are made in plaster of paris casts and can be termed 'hollow compression'. If, however, sixteen layers of gauze or eight layers of cambric are placed on the wound and the capsule then applied, 'plane compression' results (Fig. 2). The open-air treatment of wounds and burns which is so often praised has been found to be less favourable for the wound than the immediate application of a textile which is as free of irritation as possible. It can be shown by animal experiments that the mortality-rate decreases with the covering of the wound, and that the healing of the central piece of skin in the standard ring wound (Baron) can take place with only very little or no shrinkage (that is, without the loss of tissue), with the result that the cicatrization is better from the cosmetic point of view than is the case in the healing of the wound in the open air without a wound textile. These results apply only to ring wounds with a 90 per cent loss of connective tissue. Wounds of a more superficial type form their own wound cover by natural processes within thirty minutes and may not require covering by textiles. One therefore arrives at the following fundamental conclusions for the process of healing wounds: (1) open-air (in the sense of the so-called 'open') treatment of wounds is disadvantageous for deep wounds, but without any harmful influence on superficial wounds; (2) plane compression (for example, by means of a plate of 'Cellophane') will eliminate the harmful effects of the hollow compression because the plane compression will avoid congestion; (3) textile drainage allows the removal of the wound secretion with simultaneous plane compression, so that a suction effect occurs in the wound textile; this effect eliminates the harmful influence of a moist chamber; (4) unfavourable effects due to localized forces, for example gravity, in the tissue are diminished to a considerable extent by plane compression and textile drainage; (5) a delay of 6–8 hr. in covering a wound leads to serious disturbances in the healing, as is shown by the considerable increase in the mortality-rate of experimental material.

Three methods of making wound textiles are in common use: weaving (two threads, warp and weft), knitting (one thread) and fleecing. Fleecing consists of a space structure whereby the material is woven together in all directions in space and, in contrast with felting, no binder is used. Weaving is the most common process used for the production of wound textiles, and, in this connexion, the warp plays the decisive part. In our first experiments we kept the warp constant at 'metric 60', and selected a weft yarn of 'metric 80', thereby obtaining a typical gauze (Fig. 3*a*), and also a weft of 'metric 20', which gave us a cambric fabric (Fig. 3*b*). The effect of sixteen layers of gauze is equalled by that of eight layers of cambric. Although the price of gauze is lower per yard, it is more expensive in use, since sixteen layers of gauze cost about 50 per cent more than eight layers of cambric; however, the absorptive power of cambric is inferior to that of gauze. The difference in absorptive power between cambric and gauze becomes especially evident if one compares eight layers of cambric with eight layers of gauze. In the case of cambric, the wound secretion is confined to a limited area, whereas under gauze it tends to spread far into the neighbourhood. This is the case even if sixteen layers of gauze are used, though, of course, the secretion spreads less than under eight layers. An interesting observation was that sixteen layers of cambric had a more adverse effect on the healing process than sixteen layers of gauze. As the cambric fabric is thicker and heavier, it interferes with the ventilation of the wound, which then becomes soggy or wet.

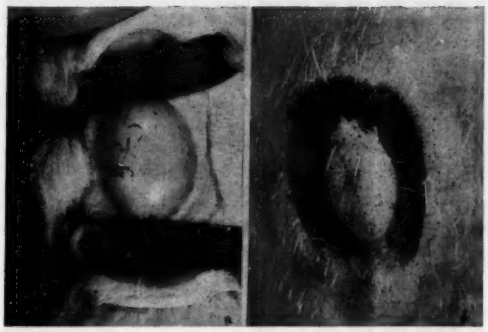

Fig. 2. Standard ring wound (*a*) covered by gauze, (*b*) without dressing; note no suppuration, no congestion and good blood supply

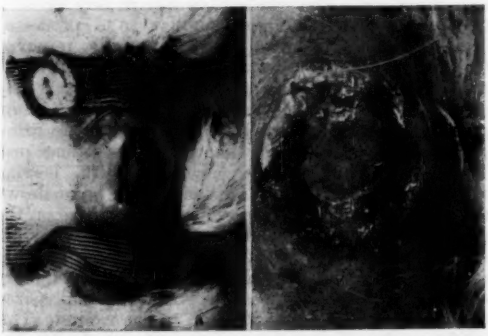

Fig. 1. Standard ring wound covered by moist chamber. Note in (*b*) suppuration, moisture and congestion

Our experiments show convincingly that the indiscriminate choice of wound textiles without regard to the number of layers used or the character of the fabric may not only prove uneconomical but may also be harmful to the wound. Selection of wrong wound textiles also affected the mortality-rate in our experimental animals. When using eight-layer cambric or sixteen-layer gauze compresses weighing 3 gm. each, the mortality-rate was 23 per cent. Animals with wounds on both sides, which were covered with eight-layer cambric compresses weighing 3 gm. each, one compress being moistened with 10 c.c. of water, showed a mortality-rate of 27·5 per cent. When the wound on one side of an animal was covered with an eight-layer gauze compress weighing 1·5 gm., the wound on the other side having an eight-layer cambric compress of 3 gm., the mortality-rate increased to 36 per cent. Although differences in the duration of the healing process were insignificant between the two kinds of compresses, the increased mortality-rate shows that the susceptibility to infection is greater under the eight-layer gauze compress owing to the spreading of the secretion underneath.

A different picture is obtained when an eight-layer cambric compress weighing 3 gm. is compared with a sixteen-layer cambric compress of 6 gm. The latter

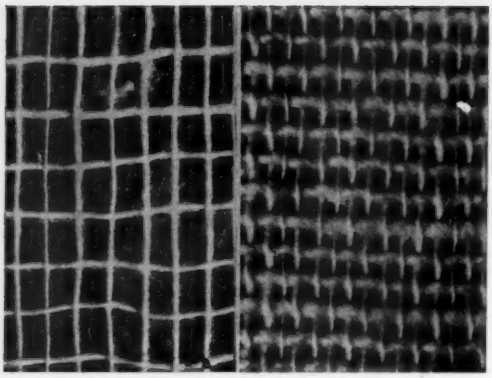

Fig. 3. (a) Gauze, a two-dimensional textile; (b) cambric, a three-dimensional textile

has an unfavourable effect on the healing of the central area due to lack of evaporation, the mortality-rate being 31 per cent. The influence of moisture is especially marked if evaporation is inhibited by covering the textile with a waterproof fabric. The central area heals with a small loss of tissue. The increased susceptibility to infection due to the lack of evaporation is shown by frequent suppuration of the wounds, and the mortality-rate rises to 40 per cent. The influence which delay of treatment exerts on the mortality-rate is especially impressive. The healing process is significantly slowed down, the central area heals with loss of tissue due to infection, and the mortality-rate rises to more than 50 per cent. This makes it clear that the first condition for successful treatment with wound textiles is to avoid delay and to dress the wound as quickly as possible.

We have been able to show that evaporation plays a decisive part in the successful application of a wound textile. Moistening of a wound textile under conditions when evaporation is uninhibited may be quite harmless. This, however, is not always the case. Moistening of the fabric might have an unfavourable effect on the wound in the case of certain textiles. For example, if very densely woven linen is moistened, it becomes still denser through swelling of its fibres. Though such fabric, through its strong absorptive power, may produce a quick drying effect, this effect soon reaches its peak and after that no further absorption takes place. The fabric lies on the wound like a wet cloth. Textiles made from cellulose wool by a fleecing process have a good drainage effect through capillary attraction when they are dry; when, however, such a fabric is like wet blotting paper, its effect on a wound is similar to that obtained by the application of textiles that inhibit evaporation.

In the assessment of wound textiles, it is advisable to sub-divide them into two-dimensional and three-dimensional textiles. The former group includes gauzes and woven linen materials, and the latter group embraces cambrics as well as all fabrics with appreciable differences in the yarn thicknesses for the warp and the weft and also knitted textiles. The use of thicker yarns decreases the number of layers.

The practical considerations to be drawn from these findings are as follows. In view of the fact that three-dimensional fabrics have been found to be the most suitable, thicker threads should be used for the making of wound textiles than have been used hitherto. The number of threads per unit length should be neither too great nor too small, for if the texture of the fabric is too dense, swelling of the fibres may close the interstices between the threads and the effect on the wound might be similar to that produced by an impermeable material. The two necessary properties for a wound textile are resistance of the fabric to shrinkage and shearing and the avoidance of adhesion with the surface of the wound. Shrinking is of two forms: primary shrinking, which takes place immediately the fabric is immersed in a liquid, and secondary shrinking, which occurs during the drying of the fabric. Primary shrinking has no significance in the treatment of wounds if the fabric is placed on the wound in a wet state, but secondary shrinking has an important influence on the healing process. A figure of 10 per cent shrinking or more has been measured for fabrics during drying; if, therefore, a fabric that is placed on a wound in the wet state dries out, movements in the area of the wound will occur which may cause pain and irritation of the wound and its surroundings. The extent of these movements may be of the order of five hundred times the size of a tissue cell. It is small wonder, therefore, that plastic surgeons prefer the open-wound treatment for Thiersch and Reverdin grafts. Whereas wound textiles made of cotton and bought on the open market show considerable shrinkage, specially made wound textiles of cellulose wool are found to be shrink-resisting.

The problem of resistance to shearing forces has yet to be solved for gauze. Owing to its loose texture, movements of the threads within the fabric take place continuously, which is not the case in cambric fabrics. After use, cambrics show only insignificant changes in the position of the threads within the fabric caused by the drying of wound secretions. In contrast, loosely woven gauze is sometimes completely destroyed in parts by the drying secretions. Shrinking through drying and lack of resistance of the fabric to sheering forces are factors which operate against one of the basic requirements of wound treatment, namely, immobilization. It should therefore be our aim to create wound textiles that remain static. The extent of shrinking and, with it, of movement within the fabric may vary locally inside the area of a wound. That is perhaps a possible explanation for the fact that sometimes we observe a sudden localized deterioration of part of a wound.

The problem of the adhesion of the wound textiles has not yet been solved. All experiments on the impregnation of fibres with the aim of eliminating adhesion have failed, no matter how logically they were built up. The crude fibre has in any event a tendency towards adhesion similar to a processed fibre. The wax-pectin layer is usually removed from crude fibres through the steeping process, and, in order to eliminate the adhesion thereby caused, unnecessary attempts are made to compensate for the removal by impregnating the fibres with carbo-waxes. Why should the steeping process not be carried out less drastically, leaving some of the wax pectin? Experiments have shown that the crude fibre has a favourable influence on the beneficial effect of penicillin applied externally, as well as being generally favourable to wounds in other respects as well. The demand for a satisfactory absorptive power which is always being emphasized may also be a cause of irritation to the wound. This is shown by numerous experiments made on the comparative merits of raw cotton and finished cotton

applied immediately to a wound. It has been found that all wound textiles have a detrimental influence on the wound when their application is delayed by as little as 6–8 hr. The infections which result thereby may be countered by the external use of penicillin. All finishing processes for wound textiles should be studied from the pharmacological and toxicological points of view. This applies particularly to cellulose wool, as the crude form, which has a yellowish tinge and is glossy, has been proved to have a most favourable influence on wounds; both matting with titanium dioxide and brightening with optical whiteners are frequently the cause of irritation to the wound. Even the diemoptical whitening of the crude cotton fibre has been proved to have disadvantages when used as a wound dressing; that is the reason for dispensing, from a surgical point of view, with a washing powder which contains optical whiteners.

Accordingly, all processes should be dispensed with which no longer have any scientific foundation, but rather only serve to make the fabric more pleasing to the eye of the purchaser. An unlimited new field offers itself to wound research: from among the numerous types of natural fibres or the more readily studied variations of synthetic fibres, the best fibre must be sought out and then processed into a wound textile with the most suitable yarn thickness and position of the threads. Only the best is good enough for the patient. This can only be achieved by strict standardization of products. At present in Germany no standardization exists.

ARTIFICIAL PRODUCTION OF IMMUNOLOGICAL TOLERANCE

Induced Tolerance to Heterologous Cells and Induced Susceptibility to Virus

IN 1949 Burnet and Fenner[1] postulated that antibody production against a particular antigen can be specifically suppressed by exposure to the same antigen during embryonic life. The first demonstration of this effect had already been given by Owen[2]. He found that dizygotic calf twins, which had long been known during fœtal life to possess vascular anastomoses between their placentæ, contained after birth a mixture of two sorts of blood cells, one corresponding to its own genotype and the other corresponding to the genotype of its twin. The persistence in later life of this blood-cell mosaic could clearly only be explained by assuming that hæmatopoietic cells transplanted during fœtal life failed to provoke the antibody response which is the usual response to homotransplantation of living cells. The next important contribution was that of Medawar, Billingham *et al.*[3], who showed that such binovular twins several months after birth were also tolerant to mutually exchanged skin grafts. The tolerance to skin was sometimes only partial; but in most cases was described as complete. Neimann-Sørensen, Gammeltoft and Simonsen[4] later showed that even a whole kidney transplanted from one cattle twin to the other of a pair which had a typical blood-group mosaic functioned for five months.

The decisive step which brought the principle of immunological tolerance from the sphere of Nature's eccentricity into the domain of an experimental method of possibly very wide applicability was the artificial production of a similar type of tolerance. This was done by Billingham, Brent and Medawar[5] and by Hašek[6]. The former group of workers injected chick and mouse embryos with living homologous cells and showed that these were able in post-natal life to accept skin grafts from the original donors. Hašek developed a method of producing parabiosis of avian eggs through the chorioallantoic membranes, and showed that chicks so treated during embryonic life failed to respond with antibody production when later challenged with each other's blood.

The present investigations were carried out on birds by the method devised by Billingham, Brent and Medawar, and had a threefold purpose: (1) investigation of whether tolerance could be acquired to cells of foreign species; (2) if so, whether the tolerance would also extend to a virus from the donor animal to which the recipient was not normally susceptible; (3) whether a sexual cross between species which is not normally possible could be made so by means of acquired tolerance. Positive answers to the first two questions have been obtained; the answer to the third awaits the sexual maturation of the treated birds.

Chick embryos (Brown Leghorn) were injected intravenously with blood from adult turkeys or geese, and turkey embryos (American Mammoth Bronze) with adult chicken blood. Natural agglutinins occur

Table 1

Exp.	Recipients	Donor	T_1 Titres before immunization (range)	T_2 Titres after immunization (range)	Individual values of T_2/T_1	Significance of difference between means of log T_2/T_1 for experimental and control groups (evaluated by the t-test)
(I) Injected in the egg	Chicken 5	Turkey	2–16	2–32	4 1 2 1 2	$t = 3{\cdot}08$ $0{\cdot}01 > P > 0{\cdot}001$
(I) Normal controls	12		4–32	16–512	8 16 4 64 4 4 2 4 32 4 8 16	
(II) Injected in the egg	Chicken 8	Goose	$\leqslant \frac{1}{4}$–64	32–512	2 4 128 2 64 4 128 2	$t = 1{\cdot}29$ $0{\cdot}3 > P > 0{\cdot}2$
(II) Normal controls	14		$\leqslant \frac{1}{4}$–64	32–1,024	16 64 64 128 16 128 16 32 128 16 256 32 32 32	
(III) Injected in the egg	Turkey 6	Chicken	2–8	2–32	8 1 1 1 2 1	$t = 3{\cdot}21$ $0{\cdot}01 > P > 0{\cdot}001$
(III) Normal controls	7		2–8	8–128	4 32 8 16 16 2 4	

Antibodies in Exp. I and II were determined after one immunizing injection, in Exp. III after two injections

in the serum of each of the species against red blood cells of the other two. These natural antibodies are not present in the newly hatched birds but develop after four to six weeks. The average titre of natural antibodies in chicken against turkey blood cells was significantly lower in the treated group of twelve birds five weeks after hatching as compared with thirty-nine normal controls. At ten weeks, sera of two of the test birds still did not contain antibodies to turkey blood cells although they contained antibodies to goose blood cells, of which the birds had had no embryonic experience. All controls had developed anti-turkey antibodies before that age (thirty-eight of thirty-nine at six weeks). There was no indication of delayed formation of natural agglutinins against goose blood in chicks which had, in embryonic life, been injected with goose blood.

Some previously treated birds, together with normal controls, were challenged five to six weeks or later after hatching by injections of blood cells from the original donors in order to see if formation of immune antibodies would be suppressed. The principal outcome of this experiment is shown in Table 1.

As seen from the last two columns of Table 1, there is in all three experiments an indication of diminished antibody response in pretreated birds as compared with normal controls. The difference is significant in experiments I and III, but not in experiment II when the test group is considered as a whole. Nevertheless, five of eight test animals in experiment II gave a lower immune antibody response than any of fourteen controls.

In experiment I, immunization was repeated four times with three test animals and all twelve controls. All injections and antibody determinations were done simultaneously for the two groups. Antibodies against the donor turkeys' blood cells were determined on the fourth day after the last injection. The findings are given in Table 2 and show lower values for all test animals than for any control.

Table 2. Titres of Antibodies against Turkey Blood Cells after Five Immunizing Injections

Test animals			8	16	4							
Controls	64	64	32	64	64	128	64	64	64	64	64	64

The tolerance of the three test animals of Table 2 later broke down, when blood from turkeys other than the original donor was injected. It is not possible to decide whether this is due to antigens in the other turkeys' blood, for which the test animals had no embryonic experience, or if it is only a quantitative question.

It thus appears that some degree of tolerance to heterologous blood can be brought about by specific treatment of the embryos. Moreover, it seems that a state of tolerance is more readily acquired between chicken and turkey than between chicken and goose. It is natural to correlate this fact with the closer taxonomic relationship which exists between the two former species as compared with the two latter ones.

In no case, however, is there evidence that complete tolerance has been achieved. Most of the tolerant birds included in Table 1 failed to maintain the acquired tolerance when immunization was repeated or when heavier doses were employed. No attempts were made to test an eventual tolerance to skin grafts.

To investigate the possibility of an altered virus–host relationship in tolerant birds, some experiments in collaboration with Dr. R. J. C. Harris have been performed on infection of turkeys with Rous virus. Duran-Reynals[7] has reported induction of sarcoma in young turkeys after injection of unfiltered extracts from Rous chicken sarcoma. He found, as also occurs in chickens, a decline of susceptibility with age. With the turkeys used in our experiments, this decline was markedly shown by the fact that ten out of twelve one-day old and four out of six one-week old turkeys developed sarcomas, whereas six three-week, six six-week, and one ten-week turkey proved refractory. All virus injections were made intramuscularly in the leg and the preparation was cell-free.

If, therefore, by exposure to chick blood during embryonic life turkeys acquire an increased susceptibility to Rous sarcoma virus, this can only be demonstrated clearly at three weeks or later after hatching. Three turkeys which had been injected intravenously with 0·1 c.c. of blood cells from young chicken at the thirteenth day of incubation were, when eight weeks old, inoculated with the same virus preparation in the same dose as had been used for the normal turkeys. Two out of three developed sarcomas at the site of inoculation. No metastases were found when the birds were killed five weeks after inoculation. The application of Fisher's[8] exact method to the difference between the treated and control birds gives $P = 0{\cdot}025$, which lies beyond the conventional level of statistical significance.

The biological significance is obviously further increased by the fact that all test animals were older than all but one of the controls. The applicability in virology of this principle of acquired susceptibility deserves further investigation. It is possible, for example, that the method could be used for the attenuation of certain viruses.

A full account and discussion of the findings reported here will appear elsewhere. I was enabled to do this work through the hospitality and support of the Chester Beatty Research Institute, and wish to thank Prof. A. Haddow, director of the Institute, for his interest and encouragement.

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Immunological Effects of Experimental Embryonal Parabiosis

According to Burnet and Fenner[1] and also Lopashov and Stroyeva[2], the inability to react against autologous antigens by the formation of antibodies develops during fœtal life (when the embryo is not yet able to produce antibodies), by the action of the antigens of the embryo's own tissues on the reticulo-

endothelial system. According to Burnet and Fenner, a similar inability to form antibodies can be provoked by even a foreign antigen entering the reticulo-endothelial system during this stage. The experiments of Burnet, Stone and Edney[3], in which living influenza virus *A*, bacterial virus *C* 16 and human erythrocytes were introduced into chick embryos, did not confirm their hypothesis. In agreement with the theory are, however, the findings of Owen[4] in respect of bovine twins. In the case of twins this phenomenon is due to placental anastomosis, that is, to natural embryonal parabiosis.

We have worked out a method of experimental embryonal parabiosis in birds[5]. Incubated eggs are used at the stage (chick 8–12th, duck 10–15th day of incubation) when the chorioallantoic membrane has begun to occupy most of the space under the shell. At the pointed end of the egg, where the major allantochorionic vessels ramify, an oval hole, 1–2 cm. in diameter, is drilled. After removing the greater part of the shell membrane underlying the hole, a small piece of embryonic tissue (usually the blastoderm of an egg incubated 20–40 hr.) is applied to the exposed chorioallantoic membrane and another egg with a corresponding aperture is applied on the other side. The junction is fastened by paraffin wax. The joined eggs are further incubated and turned in the normal way. As it is the extra-embryonal circulation which is connected, the parabiosis is interrupted at hatching. We confirmed the exchange of blood by the detection of the partner's erythrocytes in the blood of the parabiont by agglutination tests immediately after hatching. The degree of exchange can thus be quantitatively evaluated.

We found that no antibody production could be elicited by reciprocal immunization of adult chicks which had been joined during their embryonic development by parabiosis, whereas any normal chick immunized by the erythrocytes of any other chick forms isoagglutinins[5]. These parabionts do not, however, lose the ability to form isoagglutinins when immunized by erythrocytes of chicks other than their partner. By the absorption of the iso-immune serum prepared in a third bird against erythrocytes of one of the partners with the erythrocytes of the other, it has been demonstrated that the antigen composition of the erythrocytes of the two partners differs. In this respect, they differ from bovine natural embryonal parabionts, in the blood of which erythrocytic mosaicism persists. They also differ in another respect: they are fertile, as our two pairs of heterosexual parabionts show. We are endeavouring to find how long this suppression of reactivity lasts. In one of our pairs, in which immunization had initially failed to provoke antibody formation, one two-year-old parabiont formed agglutinins against the partner's erythrocytes after the fourth immunization, whereas its partner did not. Similar results with respect to the experimental suppression of immuno-biological response have been described by Billingham, Brent and Medawar[6] with respect to skin transplantation in mice and chicks. We have confirmed their results by skin transplantation in chick parabionts[7].

In interspecific embryonal parabionts between chick and duck, an inability to form antibodies was not found. In all individuals of both species there are natural heteroagglutinins against erythrocytes of the other species. In parabionts these natural antibodies invariably appeared in the same quantity as in controls. When immunizing adult individuals in their first year of life, antibodies were also formed in both parabionts—in chicks in the same quantity as in the controls (Table 2), and in ducks in a smaller amount (Table 1; see also ref. 8). Each figure in the tables represents the titre of an individual; animals in one line (parabionts and controls) were immunized by the same donor. In contrast to the parabiosis between the chicks, it made no difference whether the immunization was performed by erythrocytes of the parabiotic partner or of any other individual.

Table 1. Titres of Immune Agglutinins against Chick Erythrocytes in Ducks

Parabionts	Controls
2*	32† 64, 32
4*	32, 64
8*	258
4, 4	128, 128
4	32, 8
64‡	64
	32, 64

* Animal immunized by erythrocytes of embryonal parabiotic partner.
† Parabiont in which the exchange of blood was excluded by agglutination test.
‡ Exchange of blood not unequivocally demonstrated.
All parabionts or their partners were tested by agglutination immediately after hatching for the exchange of erythrocytes.
For earlier material, in which embryonic erythrocyte exchange was not tested, see Frenzl *et al.* (ref. 8).

Table 2. Titres of Natural (in parentheses) and Immune Agglutinins against Duck Erythrocytes in Chicks

Parabionts	Controls
64 (16), 256 (32)	64 (4), 64 (8)
128 (2)	128 (2)
256 (8)*, 256 (1)	256 (8)
512 (4)*†	128 (16), 1,024 (2)
128 (2)	128 (2)

* Represents an animal immunized by the erythrocytes of its embryonal partner.
† The skin of the duck partner was transplanted on the fifth day after hatching, the transplant surviving sixteen days.
All parabionts have been tested by agglutination immediately after hatching with respect to the exchange of erythrocytes.

We thus succeeded in causing an absolute suppression of antibody formation only by the action of homologous blood cells during embryogenesis. Heterologous blood cells did not have this effect. We obtained similar results in our embryonal parabionts with skin heterotransplantation[7]. We are continuing to study the problem of whether the antigen which is able to suppress the formation of antibodies must be of the same species, or whether this effect eventually can be obtained by the antigen of a foreign but phylogenetically related species. We are investigating this problem on chick–turkey and chick–pheasant embryonal parabionts. In any event, our results prove that in complete suppression of antibody formation caused by exposing the embryo to a foreign antigen, the character of the antigen is of importance. This fact was not taken into consideration by Burnet and Fenner.

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LETTERS TO THE EDITORS

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Crystal Structure of Benzene : a New Type of Systematic Error in Precision X-Ray Crystal Analysis

Last year, two of us gave a preliminary account[1] of an X-ray analysis of crystalline benzene from which a C—C bond-length of 1·37$_8$ A. was derived by differential syntheses with finite series corrections. We have since been able, by means of electronic computor programmes devised by Miss D. Pilling of this Department, to calculate Fourier maps and difference maps in the plane of the molecule, which clearly show that the thermal motion is markedly anisotropic, and detailed quantitative study shows that it is such as to produce a systematic error in the bond-length which is by no means negligible.

We have carried out, on the University of Manchester electronic computor, five cycles of refinement of the anisotropic thermal parameters of the carbon atoms, and find that the mean values of the components of the atomic temperature-factor B are :

Perpendicular to the plane of the ring	$4{\cdot}8 \times 10^{-16}$ cm.^{2}
Radially in the plane of the ring	$4{\cdot}5 \times 10^{-16}$ cm.^{2}
Tangentially in the plane of the ring	$7{\cdot}4 \times 10^{-16}$ cm.^{2}

The difference of $2{\cdot}9 \times 10^{-16}$ between the last two figures shows, in agreement with nuclear resonance experiments[2], that an important part of the thermal motion of the benzene molecule at − 3° C. consists of rigid-body oscillations about its senary axis. Since the motion of an atom on an arc of a circle must produce a time-averaged electron distribution the maximum of which is displaced towards the centre of the arc, this oscillatory motion must cause the radius of the benzene ring, and therefore the C—C distance, to appear shorter than is actually the case. Displacements in the same sense, although probably smaller in magnitude, arise from oscillations about axes in the plane of the molecule. Detailed analyses of these effects indicate that the correction to the bond-length is at least 0·010 A. and is probably about 0·015 A. ; the corrected C—C bond-length derived from our work is about 1·39$_2$ A., which is now not significantly different from the value 1·397 A. obtained by Stoicheff[3]. Full details of our work will be submitted for publication shortly.

The computations involved in an anisotropic thermal motion analysis are very lengthy, and our work on benzene was only made possible by the availability of the University of Manchester computor. In most cases the corrections may well be too small to justify the computation which would be involved ; but it is clear that the possibility of systematic errors in atomic positions due to angular oscillations of the molecules (or of parts of them) arises in nearly all crystal structure analyses.

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The Serpent Spring

In the course of investigations concerned with the problem of obtaining large elongation or rotational effects by small variations of a force, the following peculiar behaviour of spiral springs has been observed.

A flat spiral spring, as an ordinary clock spring, is fixed at, for example, its inner end. At the outer end a force is applied in a direction perpendicular to the plane of the undeformed spiral. If this force is sufficiently strong, it deforms the spiral spring to a shape which resembles a lifting and uncoiling serpent, as will be seen if Fig. 1 is inverted. Therefore it may be called a 'serpent spring'. Such a spring is very sensitive, under certain conditions, to very small variations of the deforming force either in its magnitude or, in special circumstances, its direction. This sensitivity shows both in variations in length of the spring and in twist.

The sensitivity depends on the inclination of the acting force to the plane of the original spiral. At certain characteristic angles, for a definite magnitude of the acting force, the spring becomes extremely sensitive (critical region). The spring generally shows two different critical shapes. These depend upon the sense of inclination, for example, inclining the clamped end upwards (Fig. 1) or downwards. Fig. 1 has been obtained by photographing a spring in three different states on the same film, corresponding to equal steps in increasing weight. The spring is shown shortly before the critical state ; the shapes are reversible, that is, the spring returns to the same

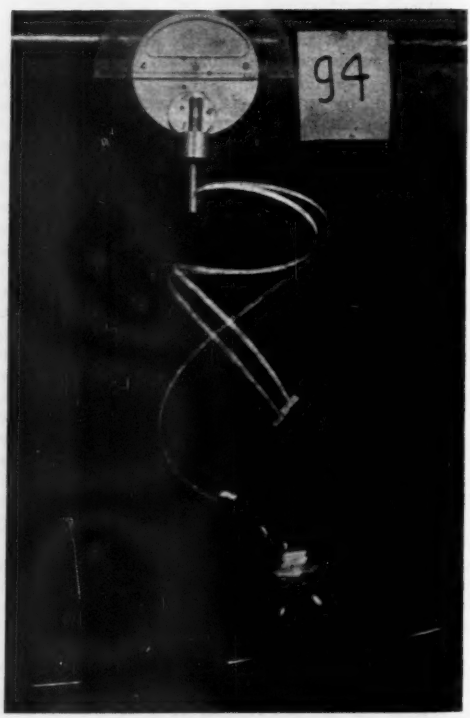

Fig. 1. Critical shapes of a serpent spring
Inclination = + 12·5°. Spring steel, $a = 2{\cdot}5$ mm., $b = 0{\cdot}2$ mm. Original spiral : 1^1 turns ; outer diameter, 100 mm. ; inner diameter, 80 mm. Loads : 9·6 ; 10·1 ; 10·6 gm.

shape on removing the additional weights. As can be seen, equal steps in loading cause widely different deformations. The step from the second to the third state corresponds to the region of high sensitivity. A pointer was fixed to the scale pan, and from this the twist accompanying the variations in shape can be seen easily.

Using values of inclination which surpass the critical angle, at a certain weight which exceeds W_{cr}, the spring suddenly jumps to a second 'lower' state. If now the loading weight is reduced, length and twist show only small variations, until suddenly, at a load which is less than W_{cr}, the spring jumps back to its former 'upper' state. The more the angle of inclination exceeds its critical value, the greater the area of the hysteresis loop.

To obtain the critical state, it is necessary to use springs which have an oblong cross-section with two unequal axes with a ratio of about 1 : 10 or preferably more. The longer axis has to be perpendicular to the plane of the undeformed spiral. The spring should have at least one and a half turns in its original state. Springs with more turns show fundamentally the same behaviour, but some peculiarities in detail. The material should be neither too soft nor too stiff, as lasting deformation or breakage may occur. In order to minimize temperature effects, it is advisable to use materials like 'Elinvar' or 'Ni-span-*C*'.

It is remarkable that there is proportionality between extension and twist over a wide range even when passing the zone of high sensitivity. For springs of about 15 cm. working length, the ratio is of the order of 0·5 mm./degree.

To a large extent the quantitative behaviour is given by

$$W_{cr} = k.E.\frac{ab^3}{d^2}$$

where W_{cr} is the critical weight, k a constant (for springs of the shape used in the experiments mentioned above it is equal to 0·4 for negative inclination), E is the modulus of elasticity, a is width and b is thickness of the spring. The 'sensitive' length d is about πr, in springs of the type of Fig. 1 where r is the mean radius of the winding where the critical deviation occurs.

Without much difficulty the serpent spring is able to show changes in the acting force of one hundred-thousandth by a twist of 0·2°. The variations in length connected with it depend on the absolute dimensions. A serpent spring of this state of sensitivity, having a length of about 10 cm. between clamp and end and showing a ratio of lengthening to twist of 0·4 mm. per degree, extends by 80μ on increasing the force by one hundred-thousandth. This corresponds to the lengthening of a normal helical spring of more than 25 ft. extended length.

The serpent spring may also be used in an inverse form, where the force produced by the spring is changed by changing the inclination of the system.

I wish to thank Prof. A. O. Rankine, Mr. R. Davies and Dr. D. T. Germain-Jones for their interest, and the chairman of The British Petroleum Co., Ltd., for permission to publish this communication. A detailed paper will be published elsewhere[1].

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[1] See also Brit. Pat. 711205, 711206.

A Slip-band Exudation Effect observed in Pure Aluminium

Earlier work on the fatigue behaviour of aluminium — 4 per cent copper alloy had revealed that material was exuded from some of the active slip bands during the later stages of the fatigue test[1]. This phenomenon is generally associated with materials which are unstable under the action of fatigue stresses, for example, supersaturated solid solutions. We believe the exudation to be produced by the action of the cyclic stresses on a thin sandwich of material depleted of solute atoms by localized over-ageing.

Annealed pure aluminium does not exude material from the slip striations, but these regions grow in width; and interferometric measurements show that corrugations may form. It is, however, possible in lightly cold-rolled pure aluminium to produce a type of exudation which is similar to that produced in the alloy. This is shown in Fig. 1. This effect is due to very local recrystallization of the disoriented matrix under the action of the cyclic stress, and the subsequent exudation of this softer material. If the material is heavily cold-rolled before fatiguing, the

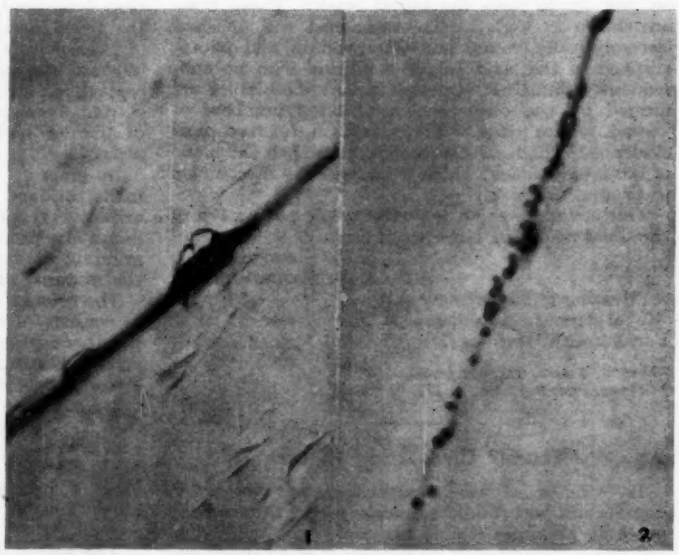

Fig. 1. Exudation produced on lightly cold-rolled pure aluminium fatigued at room temperature. × 1,500

Fig. 2. Pure aluminium fatigued at room temperature and afterwards polished electrolytically. × 3,000

recrystallized zones become too widespread to behave in this manner. Under these conditions, eruptions of larger volumes of material occur at the specimen surface.

From these and other observations made in this laboratory, it appears that exudation is the direct result of cyclic stresses deforming a sandwich of material which is softer than the matrix. Whether this material is a zone depleted of solute atoms as a result of localized ageing or local recrystallization in a pure metal, the final mechanism of failure is the same, namely, the formation of a structural 'soft spot' or stress concentration by the action of cyclic stresses.

Orowan has suggested[2] that all metals contain soft spots which may deform plastically under the action of cyclic stresses. According to him, these soft regions work-harden, and, depending on the geometry of the soft spot and the stress applied through the elastic matrix, fracture may occur or the plastically deforming region may work-harden until it behaves elastically. Our observations now suggest that although soft spots exist in the crystals before the application of cyclic stress, these are rapidly removed by small slip movements. The soft spots in which fatigue cracks eventually form are not these pre-existing structural inhomogeneities, but ones produced later by the action of the fatigue stresses. As these regions are produced at a later stage in a matrix which was originally more homogeneous, it is unlikely that the process will be reversed and work-hardening again occur before final cracking.

It is suggested that the fatigue process can be divided into two stages. During stage 1, small atomic rearrangements are occurring under the action of the cyclic stress; stage 2 begins when these rearrangements have produced a structural soft spot which, during this stage, is heavily deformed and a crack appears. In pure aluminium these conditions first of all produce a number of discrete holes which later on join up to form the initial crack. These holes are shown in Fig. 2. This specimen was polished electrolytically before and after testing and photographed in the 'as-polished' condition with no subsequent etching. It is probable that these holes are formed by the condensation of large numbers of vacant lattice sites. There is also microscopical evidence for high tensile stresses normal to the plane of the fatigue crack, which would aid this mechanism to produce a crack.

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Vapour Circulating Pumps

In studies of the composition of vapour in equilibrium with liquid mixtures of the atmospheric gases at pressures near 1 atmosphere, a method of procuring a continuous circulation of the vapour was needed. Any pump incorporated in the system was required to operate without changing the volume of the vapour space. It was further specified that the materials from which it was constructed should not adsorb large quantities of the vapour.

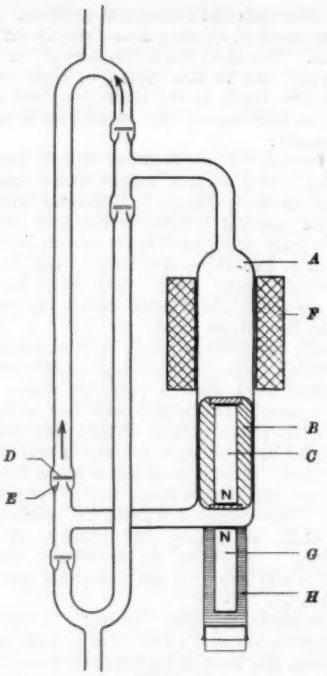

Fig. 1

A pump made in 'Pyrex' glass similar to that described by Ferguson[1], with a horizontal cylinder and solenoid-operated piston, was first constructed. It gave a vapour flow of 5 litres/hr. against a static head of 2·5 cm. water gauge. However, there was very considerable friction between the cylinder and the piston, and after a short while copious quantities of glass powder were formed, which would soon have blocked the whole of the apparatus as well as creating a large area of adsorbing surface. Grinding started somewhat slowly; but once a small quantity of powder had been produced it proceeded very rapidly.

In order to reduce the friction a new pump was made, also of glass, with the cylinder and piston arranged vertically. In due course, however, this pump also produced quantities of glass powder. This grinding action was finally prevented by changing the material of the piston, polythene being used.

The present design of the pump is shown in Fig. 1. It consists of the vertical glass cylinder *A* and the polythene piston *B*. Inlet and outlet valves are so arranged that gas flows upward, as indicated by the arrows, on both the rising and falling strokes. Each valve consists of a glass plate *D* seating on a ground face *E*. The piston *B* is 2 in. long and $\frac{7}{8}$ in. diameter and moves in a cylinder 4 in. long, in which it is a fairly close fit. It contains hermetically sealed within itself a permanent magnet *C* made of Mullard's alloy 'Ticonal *E*', $1\frac{1}{2}$ in. long and $\frac{3}{8}$ in. square cross-section.

The piston is raised by passing current through the solenoid *F* and falls freely under its own weight. In the actual pump used, the solenoid was a winding from an old transformer; but a suitable design

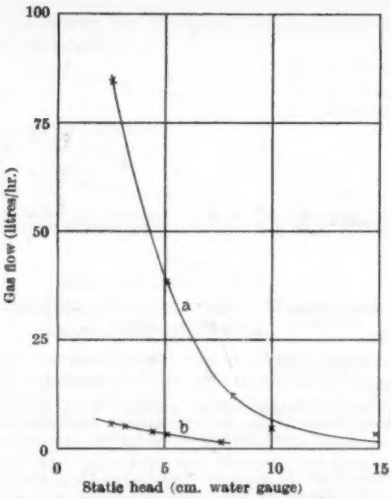

Fig. 2. (*a*) Vertical pump ; (*b*) horizontal pump

would consist of 1,000 turns of S.W.G. 22 wire with a resistance of about 7 ohms. In this solenoid a current of 1·5 amp. would be sufficient to give satisfactory operation.

In order to prevent the piston breaking through the lower wall of the cylinder, a second magnet *G* is wedged in the lower glass tube *H*, the polarity of the two being so arranged that repulsion occurs as the magnets approach one another.

This pump gives a gas flow considerably greater than that of the first one constructed. Fig. 2 shows the characteristics of both these pumps in terms of the gas flow against various static heads, when operating at 40 strokes/min. The two pumps are of similar dimensions, the swept volumes being 11 c.c. and 15 c.c. respectively for the horizontal and vertical designs. The great difference in the pumping speeds is probably due to the fact that the machined polythene piston is a much closer fit in its cylinder than was the glass piston of the horizontal pump.

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Dec. 29.

[1] Ferguson, *J. Phys. Chem.*, **31**, 1099 (1927).

Radioactivation Analysis of Arsenic in Silicon

Small traces of impurities in the range 0·001–1 p.p.m. of group V elements present in semiconductors such as germanium and silicon have a large effect on the electrical properties. Chemical methods of analysis in this range are very dependent on the purity of the chemical reagents used, and also require large sample weights. On the other hand, the method of radioactivation analysis labels the impurity atoms originally present (provided they produce radioactive isotopes), and these atoms may then be separated with added carrier and ordinary laboratory grade chemical reagents.

We have applied the radioactivation method to the problem of determining arsenic impurity in silicon in the sub-microgram range. When a sample of silicon containing arsenic impurity is irradiated with thermal neutrons in the pile at Harwell, the following reactions take place :

$$^{30}\mathrm{Si}\ (n,\gamma)\ ^{31}\mathrm{Si} \xrightarrow{\beta^-} {}^{31}\mathrm{P}$$

$$^{75}\mathrm{As}\ (n,\gamma)\ ^{76}\mathrm{As} \xrightarrow{\beta^-\gamma} {}^{76}\mathrm{Se}$$

We have found that the following is a satisfactory method for separating the arsenic impurity. The silicon is first dissolved in sodium hydroxide in the presence of hydrogen peroxide, and arsenious oxide added as carrier; the solution is then acidified with hydrochloric acid and reduced to small bulk under oxidizing conditions.

Once the sample has been taken into solution and made acid, we have followed the method used by Smales and Pate[1] for the separation of arsenic from germanium, namely, reduction to trivalent arsenic by hydrobromic acid, followed by distillation of the trichloride into water. The resulting distillate is then acidified and reduced to elementary arsenic by ammonium hypophosphite, centrifuged off, and slurried on to a counting tray, dried, weighed and the activity measured.

The chemical yield or recovery of arsenic carrier is 80–90 per cent ; at a pile factor of 10, an arsenic content of 2–3 p.p.m. gives a count of approximately 9,000 counts/min. from a 0·2-gm. sample on the third day on shelf 2 of a conventional lead castle. The identity of the radioactive isotope is confirmed by plotting the decay curve and also by the energy of the radiation from absorption measurements.

The sensitivity of the method may be estimated as follows : arsenic reaches a saturation activity of 90 mc./gm. at pile factor 1 with one week irradiation

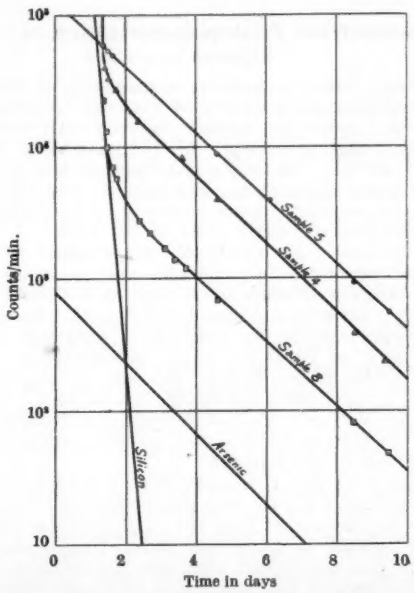

Fig. 1. Decay curves of samples of silicon

(900 mc./gm., maximum pile factor 10). If we take the detection limit of the counting system as 20 counts/min. on the top shelf of a standard lead castle with a geometry of 1/4, then 4×10^{-11} gm. of arsenic would be just detectable. It is convenient, however, to allow the silicon activity to decay before carrying out the chemical separation; thus the detection limit on the third day becomes $3{\cdot}2 \times 10^{-10}$ gm., or 0·0003 p.p.m. on a 1-gm. sample.

The accuracy of the method is limited by the uncertainty of the specific activity and shelf factors; but this limitation may be avoided by irradiating known and unknown samples simultaneously and comparing activities.

If arsenic is the major radioactive impurity, then samples may be compared by plotting the radioactive decay curves, provided that the samples are of the same size and shape. The half-life of arsenic-76 (26·8 hr.) is sufficiently different from that of silicon-31 (2·62 hr.) for the curve to be analysed into its components (see Fig. 1). When other radioactive impurities are present in similar amounts, the decay curve becomes more complex, and chemical separation with added carrier is the only certain method of analysis.

As an indication of the results obtainable by this method, samples of specially pure silicon from various sources, including some prepared in this laboratory by the decomposition of silicon iodide, have been examined. The method detected arsenic contents varying according to sample from 0·001 to 3 p.p.m.

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Jan. 13.

[1] Smales, A. A., and Pate, B. D., *Anal. Chem.*, **24**, 717 (1952).

Dye-sensitized Photopolymerization of Styrene

We have found a number of examples of dye-induced photopolymerization of styrene, in which excited dye molecules directly interact with vinyl monomers, thus promoting the polymerization reaction. Further, an interesting example has been recently found in which the initiation of polymerization can be attributed quite certainly to the energy transference in the strict sense of the word.

The systems most extensively investigated were the combinations of styrene and various cyanine dyes. When a mixture of styrene and *n*-butanol (15 : 1 by volume) containing about 6×10^{-4} mole/l. of pinacyanol iodide, for example, is irradiated by visible light at 60° C. *in vacuo*, decomposition of dye molecules occurs and at the same time polymerization of styrene is greatly accelerated. In Fig. 1 curves *a* and *b* show the amount of polymerization in the light and in the dark plotted against the time-interval of the reaction.

As seen from Fig. 1, the presence of dye does not affect the rate of the thermal polymerization; hence there is no interaction between vinyl monomer and the dye molecule in the ground state. On the other hand, it was ascertained that the dye solution in butanol *in vacuo* is not bleached at all by irradiation, so that the excited dye molecules do not decompose

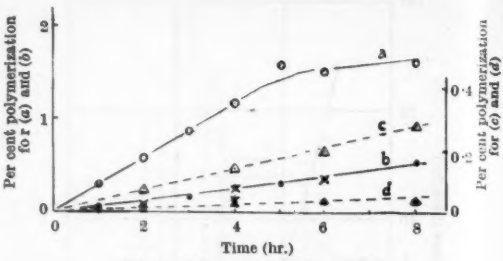

Fig. 1. Polymerization-time relation

Pinacyanol iodide (6×10^{-4} mole/l.) ○ ——, light (curve *a*); ● ——, dark (curve *b*); 60° C.
No dye × ——

Zinc-tetraphenylchlorin ($1{\cdot}1 \times 10^{-5}$ mole/l.) △ – – –, light (curve *c*); ▲ – – –, dark (curve *d*); 40° C.
No dye × – – –

The number of photons absorbed is about $1{\cdot}0 \times 10^{16}$/sec. for (*a*) and about $6{\cdot}4 \times 10^{15}$/sec. for (*c*). Matsuda V-02 filter for (*a*) and Matsuda V-*R*3 for (*c*)

of themselves. It may be concluded that the excited dye breaks down by the interaction of vinyl monomer accompanied by the production of initiator for the polymerization.

The enhancement of polymerization could be interpreted as solely due to the increase of the rate of the initiation process, and the number of initiators produced by one decomposed dye molecule was found to be about 2. The number, however, is much less than 1 at 40° C., and this would suggest that the bleaching reaction and the initiation reaction are not necessarily the same process. Both the quantum yields for photo-bleaching and photo-initiation of polymerization at 60° C. are of the order of 10^{-4}.

Analogous reactions have been established in other cyanine dyestuffs such as isocyanine, kryptocyanine, heptamethinthiocyanine and pinacyanol chloride, and similar results were obtained, at least qualitatively. In contrast to cyanine dyes, the effects of the addition of other dyestuffs, such as uranine, eosine, trypaflavine and erythrosine, were so small—if any—that quantitative investigations could not be carried out.

An interesting example of photosensitized polymerization which can be interpreted quite certainly as due to the pure transference of energy is the combination of styrene and zinc tetraphenylchlorin. The latter is an easily oxidizable compound containing the nucleus of porphin, the photo-oxidation of which was extensively studied by M. Calvin and his school and was interpreted to go via the triplet state[1]. It dissolves in styrene quite well. When styrene containing a small quantity of zinc tetraphenylchlorin is illuminated by the light of about 620 mμ *in vacuo* at 40° C., then polymerization takes place to some extent, while thermal polymerization is almost negligible at this temperature (Fig. 1, curves *c* and *d*). The important fact is that the chlorin compound is not decomposed by irradiation in this case.

In view of the facts that the substances contained in the system are only styrene and zinc tetraphenylchlorin, and that the existence of the triplet state of the latter has been established by Calvin, there seems to be no doubt that the initiation of polymerization is induced by the energy transferred from the triplet state of the chlorin compound to the styrene molecule.

We thank Prof. M. Calvin, who suggested testing zinc tetraphenylchlorin and gave us part of the

sample, and also Dr. T. Ogata, who supplied various cyanine dyestuffs.

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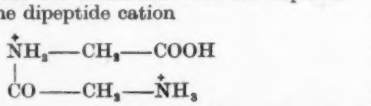
Mechanism of the Acid Hydrolysis of Glycylglycine

Numerous studies have been made on the hydrolysis of polypeptides for the determination of the composition of proteins. Usually these hydrolyses are conducted in acid solution. The kinetics of the acid hydrolysis of some dipeptides has been studied by Synge[1] and Lawrence and Moore[2]; but no mechanism has been suggested. However, in the acid hydrolysis of the amides, Benrath[3] and Euler and Ölander[4] have reached the conclusion that it is the amide cation which hydrolyses. Ingold[5] states that the rate-controlling step is a bimolecular reaction between a water molecule and the amide cation.

Synge[1] used equal volumes of glacial acetic acid and 10 *N* hydrochloric acid, and found the hydrolysis was first-order with respect to the dipeptide. Lawrence and Moore[2] used excess acid in water and found the hydrolysis was second-order, that is, first-order both with respect to the dipeptide and hydrogen ion concentrations. The results of both investigations are consistent with the explanation that it is the dipeptide cation



which hydrolyses; but the concentration of water used was large and it was not possible to ascertain its influence on the reaction-rate.

I have examined the hydrolysis of glycylglycine in aqueous acetic acid at low concentrations of water with excess perchloric acid and have obtained information on the effect of water, thus allowing a mechanism to be assigned to the hydrolysis. The hydrolysis was studied by the sealed-tube technique and its extent determined by titrating the excess perchloric acid with sodium acetate in glacial acetic acid, with methyl violet as the indicator.

Glacial acetic acid was chosen as the solvent, because in this, amines and peptides are strong bases and perchloric acid is a strong, completely ionized acid. It was also possible to vary the concentration of water. Therefore with excess perchloric acid, glycylglycine will be present as glycylglycine hydroperchlorate. Under these conditions the rate of hydrolysis at low concentrations of water was found to be given by:

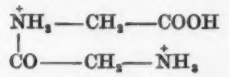
$$\text{Rate} = k_2\,[\text{glycylglycine HClO}_4]\,[\text{H}^+]$$

The results given in Table 1 show that, over a tenfold change in the water concentration, there is a very slight variation in the velocity constant and the rate is practically independent of the water concentration.

Table 1. Second-Order Constant for the Hydrolysis of Glycylglycine in Aqueous Acetic Acid with Perchloric Acid

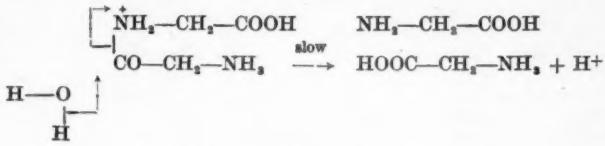
Water (per cent by vol.)	$k_2 \times 10^4$ sec.$^{-1}$ gm.-mol.$^{-1}$ l. 100° C.	120° C.
0·5	1·33	5·46
1·0	1·55	6·06
2·0	1·50	6·36
5·0	1·26	5·42

Since the peptide nitrogen is much less basic than the terminal amino group, then the dispositive ion



will be present in small concentrations which will be proportional to [glycylglycine $HClO_4$] [H^+].

The determinations by Noyce and Castelfranco[6], and Smith and Elliot[7], of the acidity function of strong acids in acetic acid, show that the hydrogen ion activity at low concentrations of water decreases with increasing water content. A reaction in acetic acid catalysed by hydrogen ions should therefore be retarded on the addition of the water; but since such an addition causes no change in the rate, it is to be concluded that the water has an accelerating effect which approximately compensates the retardation. This accelerating effect can be explained if the mechanism is a bimolecular reaction between a water molecule and the dipeptide ion as follows:



These results will be described in more detail elsewhere.

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Reactions between Quinones and Proteins

The phenolase complex, by which I mean that pair of enzymic activities occurring together and associated with copper-protein, which catalyses the *o*-hydroxylation of phenols and dehydrogenation of *o*-diphenols, is found in organisms throughout the phylogenetic scale, and catalyses the formation of quinones from *o*-diphenols. These enzyme-generated *o*-quinones react with proteins to form, *inter alia*, the sclerotized cuticles of arthropods and other phyla[1], the sepia of squid, and the melanins which colour the teguments, feathers, hair and eyes of the vertebrates[2]. In this communication I wish briefly to describe some hitherto undescribed phenomena which appear to play important parts during the interaction of protein–diphenol–phenolase systems.

Peptide effect. Amines react readily with *o*-diphenol–phenolase systems in the following way[3]:

A. Catechol + [O] $\xrightarrow{\text{(phenolase)}}$ *o*-quinone + H_2O.

B. *o*-Quinone + amine → amino-hydroquinone

C. Amino-hydroquinone + *o*-quinone → amino-quinone + catechol

The formation of *o*-quinone from catechol in the presence of phenolase (reaction *A*) is very rapid and consumes one atom of oxygen per molecule of catechol oxidized. In the presence of amino or sulphydryl groups, coupling reactions of type *B* take place. The oxidation-reduction potentials of the products are such that these coupling reactions are followed by the reductive re-formation of catechol (reaction *C*). The enzymic re-oxidation of the re-formed catechol then leads to an overall consumption of a second atom of oxygen per molecule. Under adequate conditions, the rate of the coupling reaction can be measured by the initial rate of consumption of the second atom of oxygen, and by the development of the absorption spectra of the amino-quinones. Using these techniques, we find that the rate of the coupling reaction (*B*) is markedly influenced by the nature of the substituents on the nitrogen atom, increasing, for example, in the order butyl amine, glycine, glycylglycine and glycylglycylglycine, and in the order: diethylamine, proline and N-terminal proline (as in the protamine, salmine). The peptide bond thus has a characteristic effect upon the rate of reaction between enzyme-generated *o*-quinones and amines; the magnitude of this effect appears to bear some relationship to $pK_a(NH_3^+)$ or $pK_a(NH_3^+)$ in any series, but since the coupling rate of proline ($pK_a = 10{\cdot}6$) is comparable to that of glycylglycylglycine ($pK_a = 7{\cdot}9$)[4], the factors which control the rates of reaction of quinones with zwitterionic amino-acids and peptides are not identical with the factors which determine the pK_a values of the amines.

Substrate binding and coupled oxidations of protein derivatives. We also find that the reactions of enzyme-generated *o*-quinones with peptides or proteins produce N- and S-catechol derivatives which cannot act as substrates for diphenolases. In the presence of excess free *o*-quinone, however, catecholic proteins are oxidized to the corresponding quinonoid proteins. The following instances are illustrations. In a system containing catechol and crystalline bovine serum albumin in molecular ratios between 1/1 and 3/1, a total of one atom of oxygen is consumed per molecule of catechol enzymically oxidized, the product remaining colourless. In systems containing more than three molecules of catechol per molecule of albumin, relative oxygen consumption is sharply increased and the products have absorption spectra with a maximum at 480 μ, corresponding to the spectra of 4-amino-*o*-quinone derivatives. Similarly, in systems containing catechol and glutathione in molecular ratios up to 0·8, the total oxygen consumed as a result of enzymic oxidation remains at one atom per molecule of catechol. When the molecular ratio is increased to 0·9 and above, total oxygen consumption increases very sharply to 2·8 atoms per molecule of catechol. This sharp break is accompanied by a marked difference in the colours of the final products, namely, from colourless (max. 255 and 285 μ) to deep purple (max. 270, 320, 390 and 540 μ).

Thus, the reactions occurring during the interaction of catechol–diphenolase–protein systems appear to be dependent upon the heightened reactivity of N-terminal amino-groups towards quinones, and upon the molecular ratio of the diphenol (that is, *o*-quinone) to peptide or protein. When these ratios are low, catecholyl proteins form and persist even in the presence of excess phenolase; but when the ratio is high, coupled oxidations of catecholyl proteins to quinonoid proteins readily take place. The formation of sclerotized insect cuticles, sepias and vertebrate melanoproteins may therefore proceed through N-terminal aminocatechols, N-terminal aminoquinones or the corresponding S-compounds, and end-to-end linkage of protein molecules, followed by the development of cross-linkages through the more slowly reacting ε-lysyl amino-groups and the adsorption of quinones and quinonoid polymers by secondary linkages[5].

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Chromatography of Phospholipids

There is a need for improved procedures for the analysis of phospholipids, and the brief account given here describes a technique which possesses considerable advantages.

In a typical experiment a rat was injected intravenously with 0·8 mc. of phosphorus-32 (as $NaH^{32}PO_4$) one hour before being killed. The fat was extracted from the liver and washed with 0·1 *N* hydrochloric acid to remove cations and contaminating phosphorus-32. The fat (100–300 mgm.) was treated in benzene with fluoro-2:4-dinitro-benzene in the presence of triethylamine. There is a complete reaction with all the available amino groups within two hours at 40°. The excess fluoro-dinitro-benzene and any by-products can be removed by chromatography or by distillation on to a cold finger at a pressure of less than 0·05 mm. of mercury. The dinitrophenyl-lipid, which was washed with 0·1 *N* hydrochloric acid to remove the last traces of triethylamine, was then treated with diazomethane. Secondary phosphates are quantitatively converted to tertiary esters under these conditions[1], as also is the carboxy group in phosphatidyl serine.

The fat (97 mgm.) was chromatographed on 'Hyflo-super-cel' (0·5 gm. of absorbent per mgm. of fat), yielding four main fractions which could be distinguished by their absorption spectra: (1) light petroleum eluted the glycerides and vitamin A; the phosphorus content was low, but some phosphorus was always present in this fraction. (2) Benzene or benzene–chloroform mixtures eluted a fraction with $\lambda_{max.}$ at 328 mμ (light petroleum) containing nearly equimolar proportions of dinitrophenyl groups and

phosphorus. On further chromatography this fraction separated into a fast-running fraction which contained mostly ethanolamine, while serine predominated in the slow-running fractions. (3) Chloroform containing 10 per cent ethanol eluted material with $\lambda_{max.}$ at 345 mμ (light petroleum). The molar ratio of dinitrophenyl groups to phosphorus was low (less than 0·5) and further chromatography showed that this material was a mixture. Fractions were obtained with 8–100 per cent amino-phospholipid. The specific radioactivity varied considerably and bore no simple relation to the dinitrophenol absorption, indicating that both the cephalins and lecithins present varied in specific radioactivity. (4) Ethanol slowly eluted material with little or no absorption due to the dinitrophenyl groups, and this fraction, which was not always recovered quantitatively, contained predominantly choline-phospholipids.

The specific radioactivity tended to be highest in the fraction with $\lambda_{max.}$ at 328 mμ; but some fractions with $\lambda_{max.}$ at 345 mμ were nearly as high. The final fractions had the lowest specific radioactivity, which was about a quarter of the highest value obtained.

Dinitrophenyl-octadecylamine has $\lambda_{max.}$ (light petroleum) at 330 mμ, but in ethanol it is 347 mμ. The dinitrophenyl-lipids (not treated with diazomethane) all absorb at 345 mμ. It is unexpected that some of the dinitrophenyl-lipids, after treatment with diazomethane, should still absorb at 345 mμ. The explanation of this is as yet unknown. The proportion of dinitrophenyl-lipid with $\lambda_{max.}$ at 328 mμ and at 345 mμ varies; in liver lipid there is more material absorbing at 345 mμ than at 328 mμ, whereas in brain lipid the opposite is the case.

In conclusion, it may be said that an examination of the results of several recent investigations[3], together with the present results shows that phospholipids cannot be a simple mixture of phosphatidyl choline, phosphatidyl serine and phosphatidyl ethanolamine, together with small amounts of sphingomyelin and inositol phospholipids. It now seems likely that additional molecular species are present.

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Muscle Sodium

It was recently considered[1] that the sodium content of the frog sartorius muscle may be constituted as follows:

	m. equiv./kgm.
Total mean sodium	24
Interspace	13–14
A special region sodium	6–8
General fibre sodium	2–5

It could be inferred from the evidence that the special region referred to above was either a special group of fibres into which sodium entered much more rapidly than into the fibres in general, or it was the sarcolemma of each fibre. Strong evidence has now been obtained by extensive potential measurements in the single fibre of the sartorius, using the microelectrode technique, that the region in question is not a group of fibres, and it may therefore be inferred that it is the sarcolemmas of the fibres in general[2].

It may be assumed that 2–5 m. equiv. sodium/kgm. of sodium exist within the fibres in general. The following evidence therefore leads to the conclusion that the greater fraction of this moiety is not free, but is in some way firmly held and prevented from mixing with sodium-24 during twenty-four hours.

(*a*) It was noticed that when frogs were injected with sodium-24, the sartorii removed the following day and then immersed in isotonic glucose solution containing 5 m.mol. potassium sulphate/litre, 99 per cent of the labelled sodium emerged from the muscle in 90 min. But 10 per cent of the total muscle sodium, as measured by the flame photometer or by a uranyl acetate method, remained up to two hours or more. This was confirmed in a series of experiments using the purest chemical substances and with suitable blank experiments.

Fig. 1 shows the average values obtained where the original values for the labelled sodium and for the total sodium are both regarded as 100. There is no such difference between the exit of labelled and total sodium apparent with liver.

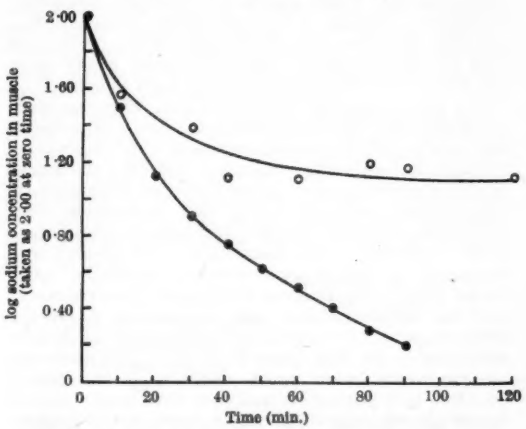

Fig. 1. Curves showing exit of total sodium (circles) and labelled sodium (dots) from sartorii into isotonic glucose containing 5 m.mol. potassium sulphate/litre

(*b*) After this, a series of observations on the ratio of labelled sodium to total sodium in the muscle and in the plasma was made. From the results obtained, there were 19·7 ± 1·0 m. equiv. labelled sodium and 24·5 ± 0·9 m. equiv. total sodium per kgm. muscle, showing a difference of 4·8 ± 1·3.

The difference would seem to indicate an even greater amount of unlabelled sodium than the immersion experiments; but the statistical variation is relatively wide and such divergence is not significant.

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Total and 'Exchangeable' Potassium in Humans

The presence of the naturally radioactive isotope potassium-40 to the extent of 0·012 per cent in potassium affords a convenient means of measuring the potassium content of humans, provided that no other radioactive elements (for example, radium) are present in the body. Of the total amount of potassium present, only some is said to be 'exchangeable', as measured by the method of isotopic dilution using the short-lived isotope potassium-42.

The total potassium content of the human body expressed as a percentage of the body-weight has been quoted as $0{\cdot}21_8$ per cent[1] and 0·35 per cent[2] by methods based on chemical analysis of human remains, while the results of Burch and Spiers[3] based on total-body radioactivity measurements indicate $0{\cdot}21_8 \pm 0{\cdot}01$ per cent (ten males and three females, aged 19–20 years), $0{\cdot}21_2 \pm 0{\cdot}01$ per cent (eleven males aged 26–41 years) and $0{\cdot}21_8 \pm 0{\cdot}02$ per cent (four males, aged 60–79 years). The amount of 'exchangeable' potassium is reported as $0{\cdot}18_1 \pm 0{\cdot}01_8$ per cent of body-weight for thirty males by Corsa *et al.*[4], who conclude that the exchangeable fraction is probably 5 per cent less than the total potassium. The mean 'exchangeable' potassium content of twenty females is given as $0{\cdot}12_8 \pm 0{\cdot}01_1$ per cent of body-weight by Aikawa *et al.*[5]. These results are generally confirmed by those of Blainey *et al.*[6], who quote $0{\cdot}17_8 \pm 0{\cdot}01_4$ per cent for seventeen males and $0{\cdot}13_7 \pm 0{\cdot}01_8$ per cent for seven females, while Edelman *et al.*[7] give the value of 0·16 per cent for fourteen females.

We have measured both total and 'exchangeable' potassium on a number of subjects; the total content was determined by measurements of body radioactivity using a total-body γ-monitor, ascribing the whole of the response to the radioactivity of potassium-40 (unpublished work by J. R.), and comparison with the radioactivity of weighed amounts of pure potassium chloride. 'Exchangeable' potassium was measured by the isotopic dilution technique, using about 50 μc. of potassium-42 injected intravenously, and the determinations were carried out 24–36 hr. after injection. We have not detected any differences attributable to this time interval. Radioactivity measurements were made with a γ-scintillation counter, and potassium analyses were made with a flame photometer. All the persons were healthy young Danish subjects, with no history of work with long-lived radioactive isotopes, and with no lengthy period of residence outside Denmark. The results for six males and four females are shown in Table 1.

Table 1

Subject No.	Sex	Age	Weight (kgm.)	'Exchangeable' potassium		Total potassium	
				gm.	% of body-weight	gm.	% of body-weight
1	M	29	75	138	0·19	148±18	0·20±0·03
2	M	30	86	160	0·19	146±18	0·17±0·03
3	M	24	68	145	0·21	163±18	0·24±0·03
4	M	22	72	106	0·15	141±18	0·20±0·03
5	M	31	74	138	0·19	174±18	0·24±0·03
6	M	23	82	174	0·21	199±18	0·24±0·03
7	F	28	59	102	0·17	111±22	0·19±0·03
8	F	18	61	116	0·19	130±18	0·21±0·03
9	F	22	56	89	0·16	113±18	0·20±0·03
10	F	17	67	101	0·15	127±18	0·19±0·03

Mean for 6 males: $0{\cdot}19_6 \pm 0{\cdot}02_2$ $0{\cdot}21_1 \pm 0{\cdot}01_8$
Mean for 4 females: $0{\cdot}16_7 \pm 0{\cdot}01_7$ $0{\cdot}19_7 \pm 0{\cdot}01_8$

The errors quoted for the total potassium contents are the probable errors associated with the statistics of the measurements; it is difficult to assess the error in individual determinations of the 'exchangeable' potassium, but repeat measurements on a few subjects suggest that it is rather less than 10 per cent. With one exception, where the difference is not significant, the 'exchangeable' potassium content is less than the total by 7–25 per cent (mean 15·2 per cent). The wide range of this difference is to be expected in view of the probable errors quoted in Table 1, and any biological variations are therefore swamped by the instrumental errors. Our results are thus in harmony with the measurements of other workers in this field, except that the difference of 5 per cent estimated by Corsa *et al.*[4] appears to be too low.

We have also measured the total and 'exchangeable' potassium contents of a patient suffering from a non-characteristic type of hereditary periodic paralysis. The results were 158 ± 20 gm. (0·24 ± 0·03 per cent of body-weight) for total potassium and only 85 gm. (0·13 per cent of body-weight) for 'exchangeable' potassium. This discrepancy has not yet been confirmed in other members of the patient's family.

The measurements of total-body radioactivity were made while one of us (J. R.) was on leave of absence from the Atomic Energy Research Establishment, Harwell.

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Distribution and Formation of Isocitritase

A new reaction of tricarboxylic acids, and the possibility of an alternate oxidative pathway, was indicated by the demonstration by Campbell, Smith and Eagles[1] of glyoxylate formation from citrate by extracts of *Pseudomonas aeruginosa*. By a preliminary fractionation of the pseudomonad extract, particularly by the removal of aconitase, Smith and Gunsalus[2] demonstrated the stoichiometry of the reaction as:

$$\text{isocitrate} \rightarrow \text{glyoxylate} + \text{succinate} \qquad (1)$$

and showed that this enzyme system, which we termed 'isocitritase', required magnesium ion and a mercapto compound as activators. Also following the lead of Campbell, Smith and Eagles, Saz[3], although he did not separate the aconitase from the pseudomonad extracts, has concluded from reaction-rates that isocitrate is the substrate, and from inhibitor data and stimulation by yeast kochsaft that both organic and inorganic activators are required. Olson[4] has also recently reported glyoxylate formation from tricarboxylic acids by *Penicillium chrysogenum* and other fungi, including baker's yeast, by what appears to be an isocitritase mechanism.

Table 1. ISOCITRITASE DISTRIBUTION (AEROBIC CELLS)

Organism* and strain	Isocitritase (units†/mgm. protein)
1. *P. aeruginosa*, 9027	1·55
2. *P. fluorescens*, A3.12	1·32
3. *P. fluorescens*, B.6bs	0·76
4. *P. putrifaciens*, 207	1·77
5. *Azotobacter agile*, 4.4	1·68
6. *Azotobacter vinelandii*, 0	1·35
7. *Acetobacter aceti*, F.4	0·86
8. *Escherichia coli*, Crooks	0·93
9. *Serratia marcescens*, 3M4	0·65
10. *Micrococcus lysodeikticus*, 4698‡	2·10

* Cells 1–9 were grown with aeration in an acetate 0·5 per cent, glutamate 0·2 per cent, ammonium salts medium. Cell paste (at 200 mgm. per ml. of *M*/50 phosphate buffer, *p*H 7·0) was oscillated 15 min. in a 10 kc./s. Raytheon oscillator and centrifuged 1 hr. at 16,000 *g* to obtain a cell extract.

† 1 unit = 1 μmole glyoxylate produced per 10 min. Reaction mixture contained: 20 μmoles DL-isocitrate, 3 μmoles magnesium chloride, 10 μmoles glutathione, 200 μmoles tris-(hydroxymethyl)-aminomethane buffer *p*H 7·6, extract 3–5 mgm. protein.

‡ Grown on a DL-malate 0·5 per cent, NZ amine 0·2 per cent, salts medium, cell extract obtained by lysis with lysozyme.

In extending earlier studies of diverse metabolic pathways in micro-organisms, the isocitritase content of several bacterial extracts under study in our laboratory was measured. The results for organisms grown aerobically on organic acids as energy source are shown in Table 1. The aerobic Gram-negative rods of the *Pseudomonas* and *Azotobacter* genera were all high in isocitritase activity, as was the related acid-tolerant Gram-negative aerobe *Acetobacter aceti*—which also possesses a complete oxidation system[1]. The two facultative Enterobacteriaceae possessed lower, but comparable, levels of isocitritase. The aerobic Gram-positive coccus *Micrococcus lysodeikticus* possessed the highest activity of any strain reported; whether the altered growth conditions, malate plus organic nitrogen source, were contributing factors has not so far been determined. The isocitritase-level in *M. lysodeikticus* would imply a suitable source of enzyme for fractionation.

The very marked alteration in enzymatic content demonstrated, in facultative and aerobic organisms, in response to growth conditions prompted us to assay extracts of representative strains from several growth conditions. *E. coli*, Crooks strain, was harvested from three media: the acetate-salts medium used for isocitritase production[2], the glucose glutamate salts medium used for keto-acid oxidase production[3], and the glucose tryptone yeast extract medium used for anaerobic growth to induce citritase formation[4]. As shown in Table 2, only the *E. coli* cells grown aerobically with organic acid as source of energy contained isocitritase. With glucose, as source of both aerobic energy and of anaerobic (fermentative) energy in the presence of citrate to induce citritase formation[4], the cells formed were devoid of isocitritase (Table 2). Thus in *E. coli*, citritase and isocitritase appear to operate anaerobically and aerobically respectively. It is also noteworthy that the isocitritase content of *P. aeruginosa* devoid of fermentative pathway to sustain growth is reduced about 50 per cent by growth on glucose instead of acetate.

Table 2. ISOCITRITASE FORMATION; EFFECT OF GROWTH CONDITIONS

Aerobiosis and growth substrate	Isocitritase (units/mgm. protein)		
	P. aeruginosa, 9027	*A. aceti*, F.4	*E. coli*, Crooks
Aerobic			
Acetate	1·55	0·86	0·93
Glucose*	0·80	—	nil
Glycerol†	—	nil	—
Anaerobic			
Glucose‡	No growth	No growth	nil

* Medium, same as for acetate (Table 1), except 0·3 per cent glucose substituted for acetate.

† Glycerol 2 per cent, NZ amino 1 per cent, yeast extract 1 per cent.

‡ Glucose 1 per cent, glutamate 0·2 per cent, yeast extract 0·5 per cent ammonium salts.

In addition, extracts of two *Acetobacter* strains, *suboxydans* and *aceti*, grown on glycerol as source of energy and of carbon in the presence of organic nitrogen[5], were devoid of isocitritase. *Acetobacter suboxydans* does not possess a complete oxidative cycle, lacks condensing enzyme, and isocitric and α-ketoglutaric acid dehydrogenase[5], and requires vitamins and at least traces of glucose or glycerol for growth[5]. This strain does, however, possess aconitase, which may imply an alternative pathway of citrate formation and/or utilization under altered growth conditions—thus the assumption should not as yet be drawn that *A. suboxydans* is devoid of an isocitritase-forming mechanism. The *Acetobacter aceti* strain, when grown on an acetate-salts medium, contains isocitritase (Table 1) and, like *E. coli*, does not form isocitritase when grown on carbohydrate (glycerol) medium.

While further studies will be required to clarify these diverse metabolic patterns, including the source of the biosynthetic precursors, it is tempting to suggest that the C_2 precursor of glycine and of C_1 may arise from both the tricarboxylic acid cleavage, presumably via isocitritase, and from glucose, possibly from 'glycolaldehyde-DPT' via transketolase reaction—the source in a given case depending on growth conditions and enzymatic patterns.

These observations also lend further credence to Krebs's suggestion of the tricarboxylic acid cycle as a precursor of biosynthetic intermediates, even though by alternative reactions of cycle intermediates[2,6], and further to emphasize that diverse pathways in the oxidative, as well as in aerobic and anaerobic carbohydrate metabolism, remain to be enumerated and clarified.

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Concentration of Iodine-131 across the Placenta of the Guinea Pig and the Rabbit

DURING the course of an investigation on the structure and function of the guinea pig fœtal thyroid, it was noted that a concentration gradient of iodine-131 is established across the placenta after a single injection of iodine-131 is given to the mother. 3 mgm. of propylthiouracil per 100 gm. body-weight was injected subcutaneously in the pregnant animals, thus preventing organic binding of iodine. Forty to forty-five minutes later the dose was repeated

and 100 μc. of carrier-free sodium iodide-131 in 2 ml. of distilled water was injected subcutaneously in the right axilla. One hour later the animal was anæsthetized with 'Nembutal' and ether, a midline abdominal incision was made, the uterus opened and the fœtuses exposed and individually bled from the umbilical cord or from the heart. Maternal blood was collected by heart puncture before and after the removal of the fœtuses. Both maternal and fœtal blood was collected in heparinized centrifuge tubes. Either 0·5- or 1-ml. samples of plasma were diluted with distilled water to a volume of 10 ml. in 12-ml. glass containers and the radioactivity counted in a Geiger–Müller multiple counter[1].

Of the ten guinea pigs studied so far, all of which were between forty and sixty days pregnant, the iodine-131 concentration in the fœtal plasma was 1·5–5 times higher than the iodine-131 concentration in the maternal blood. Because the concentration of iodine-131 in the maternal blood, as indicated by heart puncture samples before and after removal of fœtuses (a 15-min. interval), was on a rising, steady or early falling curve, the ratio found of iodine-131 in fœtal plasma to that in maternal plasma reflects a true high plasma concentration of inorganic iodide in the fœtal blood.

The iodine-131 in the fœtal blood was not precipitable by protein precipitants, and when the fœtal plasma was allowed to come to equilibrium with its maternal plasma across a semi-permeable collodion membrane, the iodine-131 concentration was found to be equal in both. The results, together with the further findings that the ratio of iodine-131 in fœtal plasma to that in maternal plasma was reversed in two guinea pigs given 100 mgm. of sodium thiocyanate, indicate that there is a transport mechanism for iodide in the guinea pig placenta comparable to that in the thyroid gland, salivary glands and gastric mucosa.

It was possible to demonstrate the same high ratio of iodine-131 in fœtal plasma to that in maternal plasma in three pregnant rabbits, all of which had a steady level of iodine-131 in the plasma at the time of removal of the fœtuses; but the existence of a similar ratio could not be demonstrated in rats.

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Urinary Excretion of a Substance after a Single Dose

The method of Stern[1] for representing experimental data seems to be useful. However, the equation of Haigh and Reiss[2] has good theoretical justification, and it seemed worth while to see whether there was any simple relation between the two formulæ. Stern derives the equation

$$x \log 2 = Q \log \frac{t}{t_0} \qquad (1)$$

to represent the data where Q and t_0 are constants and x is the cumulative excretion as a function t. Haigh and Reiss's equation is

$$x = x_{max.} \{1 - \exp(-\lambda t)\} \qquad (2)$$

where $x_{max.}$ and λ are constants. Plotting Haigh and Reiss's equation in the manner of Stern gives an effective straight line over the range $t = 0{\cdot}2/\lambda$ to $t = 4/\lambda$, and this curve then has a discontinuity and becomes the horizontal straight line $x = x_{max.}$ for greater times. This straight line yields values of $Q = a\,x_{max.}$ and $t_0 = b/\lambda$; tentative values of the constants a and b are $a = 0{\cdot}25$ and $b = 0{\cdot}1$. For values less than $0{\cdot}2/\lambda$, the curve tends to the straight line $x = 0$ as t tends to zero. This behaviour is more satisfactory than the straight line of Stern, as the latter will yield negative excretions for the period immediately after the injection. Thus it appears that in fact Stern's method is merely a convenient way of plotting a Haigh–Reiss formula.

In the case of Stern's curves (C and D), there appears to be some evidence for a discontinuity of the type predicted by a Haigh and Reiss formula, except that the second straight line is not horizontal but instead has a smaller slope than the first line. Our own experiments with inulin give curves of the same type as D, and in this case a study was also made of the plasma concentration, C_1, which could be represented by an equation

$$C = C_1 \exp(-\lambda_1 t) + C_2 \exp(-\lambda_2 t) \qquad (3)$$

where C_1, C_2, λ_1 and λ_2 are constants. Assuming simple glomerular filtration, equation (3) would yield a double Haigh–Reiss formula of the form

$$x = x_1 \{1 - \exp(-\lambda_1 t)\} + x_2 \{1 - \exp(-\lambda_2 t)\} \qquad (4)$$

where x_1 and x_2 are constants. Such a formula when plotted in the manner of Stern yields a curve of type D, and it is possible to evaluate the four constants x_1, x_2, λ_1, λ_2, from an analysis of the curve.

In the case of inulin, equation (3) is a mathematical representation of the combined effect of passage of inulin into (and out of) the interstitial fluid and glomerular filtration. Thus the constants in equations (3) and (4) are related to physiological factors in the case of inulin, and probably in the cases studied by Stern.

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I am grateful to Hough, Barnard and Bassir for suggesting that my equation may be considered as an approximation, over a limited range of t, to that described by Haigh and Reiss. This explanation may provide some logical justification for what was an empirical finding.

Fig. 1 shows a graphical representation of the Haigh and Reiss equation (solid curve), plotted on a log time-scale, together with the limits over which Hough *et al.* suggest a line of the form of my equation may be considered as a good approximation (marked G). Their suggestion that $x = x_{max.}$ for large values

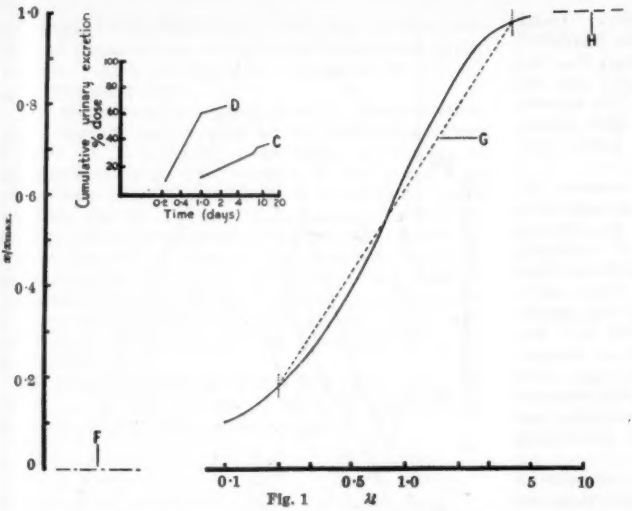

Fig. 1

of t is shown as the broken line H, and $x = 0$ when t is small as F. Their argument that the inset curves C and D provide some evidence for the existence of lines G and H is perhaps more debatable, and it appears to be more likely that these discontinuities are manifestations of changes in excretion-rate parameters.

There is one further point: their argument leads Hough *et al.* to the formula $Q = a.x_{max.}$, where $a \doteqdot 0{\cdot}25$. For line B of my original curve, $x_{max.}$ is evidently 100 per cent, so that the right-hand side of this equation is approximately 25 per cent. Q may be read from the slope of the line, and is approximately 22 per cent, and these two percentages are close enough to support the hypothesis of Hough *et al.* for this line.

When, therefore, there is evidence that the urinary excretion of a substance may be expressed by Haigh and Reiss's equation, Hough *et al.*'s suggestions provide a neat method of evaluating $x_{max.}$ and λ from a graphical representation of my equation, the former being obtained from the 'double time factor' ($x_{max.} = Q/a$) and the latter from the intercept of the line on the time axis ($\lambda = b/t_0$), when the cumulative urinary excretion is plotted against log time.

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The Binding of Vitamin B_{12} by Castle's Intrinsic Factor

Ternberg and Eakin observed that gastric juice rendered vitamin B_{12} unavailable to micro-organisms. Much attention has since been given to the binding of the vitamin by mixtures of substances, some of which possess intrinsic factor activity, and also by certain proteins, such as lysozyme, and heparin. However, it has been shown by several workers[1] that intensity of binding is not necessarily correlated with intrinsic factor activity. It was shown by Bird and Hoevet that a great variation in vitamin B_{12}-binding capacity of their intrinsic factor concentrate could be demonstrated, depending on the technique employed.

The following experiments have been carried out to determine the binding of vitamin B_{12} by a preparation of Castle's intrinsic factor[2]. The binding of vitamin B_{12} was determined by adding excess vitamin to solutions of a preparation of the intrinsic factor. Two types of experiment were performed: one in which free vitamin B_{12} was determined in the presence of the complex, and another in which the solution was ultrafiltered and the free vitamin determined in the ultrafiltrate. In all experiments the vitamin B_{12} was determined microbiologically, using a mutant *Escherichia coli* in plate assay. The results are shown in Table 1.

It will be observed that two concentrations of vitamin B_{12} were combined with a single concentration of intrinsic factor concentrate, and similarly, two concentrations of intrinsic factor were combined with a single concentration of vitamin B_{12}. The effect of doubling either of these two variable factors, while keeping the other one constant, could thereby be observed.

Some of the determinations were made by the ultrafiltration method described above. The values obtained by the two methods were of the same order. Free B_{12} estimated in the presence of the complex could not therefore be attributable to utilization of bound vitamin B_{12} by *E. coli*. These experiments are not comparable with the dialyses of Bird and Hoevet, in which the complex of vitamin B_{12} and binding factor was, in effect, being constantly washed. In the ultrafiltration experiments the complex was being concentrated, whereas the concentration of free vitamin within and without the sac remained the same.

Thus, by doubling the initial concentration of intrinsic factor concentrate from 52·5 μgm. per ml. to 105 μgm. per ml., while keeping the vitamin at the constant concentration of 100 mμgm. per ml., it was possible to increase the binding of the vitamin from a mean value of 47·5 mμgm. to one of only 66·2 mμgm. per ml., instead of approximately 100 mμgm. The respective specific binding activities were 896 mμgm. per mgm. intrinsic factor concentrate and 630·5 mμgm. per mgm. intrinsic factor concentrate; thus the lowest level of vitamin B_{12}

Table 1. SUMMARY OF B_{12} BINDING BY INTRINSIC FACTOR

Intrinsic factor (μgm./ml.)	Vitamin B_{12}/ml. added	Vitamin B_{12}/ml. bound	Specific binding capacity (mμgm. B_{12}/mgm. intrinsic factor)
105 μgm.	100 mμgm.	70 mμgm.	666
		70 *	666
		60	571
		65 *	619
52·5 μgm.	100 mμgm.	55 mμgm.	1,037
		45	849
		45	849
		45 *	849
52·5 μgm.	200 mμgm.	100 mμgm.	1,886
		110	2,075

* Results obtained by the ultrafiltration method.

gave a higher apparent specific activity. Using 52·5 μgm. of intrinsic factor concentrate, combined with 100 mμgm. and 200 mμgm. of vitamin B_{12}, the binding values obtained were 47·5 mμgm. per ml. and 105 mμgm. per ml. respectively. The specific binding activity was thus raised from 896 mμgm. to 1,980 mμgm. per mgm. of intrinsic factor concentrate.

These results show that the use of vitamin B_{12} binding by a substance or the vitamin content of a complex in following the isolation of B_{12}-binding proteins may be subject to a number of confusing variations. Gregory and Holdsworth[3] conclude that their cyanocobalamin-protein isolated from sow's milk is very similar to that isolated from hog gastric mucosa by Wijmenga *et al.*[4]. They noted only one discrepancy, and that was in the content of vitamin B_{12}; the former contained 12·3 μgm. per mgm. and the latter 23·6 μgm. per mgm. It is doubtful whether or not such results possess any absolute value, and it would seem certain that deductions concerning molecular weights are meaningless.

The present results are of interest in the light of clinical observations which demonstrate that an increase in either the amount of vitamin B_{12} or of intrinsic factor enhance the hæmatopoietic effect of their simultaneous oral administration. It is possible that the increase in binding of vitamin B_{12}, observed when the concentration of either the vitamin or the intrinsic factor concentrate was increased, might bear some relation to an increased absorption of the vitamin.

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Effect of Splenectomy on 'Antrycide' Therapy of *Trypanosoma evansi* Infection in Rats

'Antrycide', a trypanocidal drug which has been reported to be inactive *in vitro*, exerts marked chemotherapeutic activity *in vivo*[1]. This difference in activity of 'Antrycide' *in vitro* and *in vivo* may possibly be due to the drug being converted to a more active metabolic degradation product than the parent drug, or activated *in vivo* through the intervention of the reticulo-endothelial system. The first of these possibilities cannot be excluded in the present state of knowledge, as very little is known about the metabolic degradation products of 'Antrycide'. This communication presents evidence to support the latter view that the reticulo-endothelial system plays an important part in the chemotherapeutic activity of 'Antrycide' (methylsulphate salt) against *T. evansi* in rats. The strain of *T. evansi* is of equine origin, isolated at the Indian Veterinary Research Institute in 1945, and being maintained through blood passages in rats.

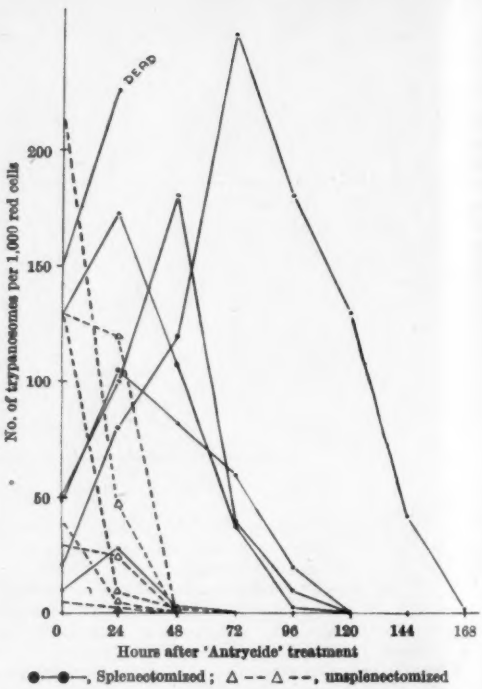

Fig. 1. Graph illustrating the course of *T. evansi* infection in splenectomized and unsplenectomized rats after 'Antrycide' therapy

Three sets of experiments were conducted, rats being used in each set. Twelve animals were divided into two homogeneous groups, one of them being splenectomized, while the others served as unsplenectomized controls. Ten days after the operation, each of the splenectomized and the control animals was infected with about 10×10^6 trypanosomes by the subcutaneous route. The course of infection in both groups was followed by daily examination of thin and thick blood smears. No appreciable difference in the prepatent period and the course of parasitæmia was observed in the two groups. During the acute phase of the infection, they were treated with 'Antrycide methylsulphate' (3 mgm./kgm.) by the subcutaneous route. Twenty-four to seventy-two hours after treatment, the flagellates disappeared from the blood of the control rats, whereas it was 72–192 hr. before they disappeared from the circulation in splenectomized ones. 'Antrycide' administered when the density of trypanosomes was fairly high could not control the progressive multiplication of the flagellates in some of the animals. The results of one set of experiments are illustrated in Fig. 1.

Similar experiments were undertaken in rats which relapsed within three to five weeks after control of the primary attack with 'Antrycide' (3 mgm./kgm.). When a fair number of organisms appeared in the peripheral circulation, about half these cases were treated with a second dose of 'Antrycide' (3 mgm./kgm.), while the remaining half were splenectomized

and treated with 'Antrycide'. The rate of disappearance of parasitæmia with the splenectomized group was also much prolonged as compared to the unsplenectomized ones.

The above results suggest that the reticulo-endothelial system participates in the chemotherapeutic activity of 'Antrycide'. Its action is similar to trypanocidal drugs like suramin in this respect, as the activity of the latter has been found to be bound up with the reticulo-endothelial system[2]. But the exact mode of participation of the reticulo-endothelial system, that is, (1) whether the drug acts chiefly in stimulating the immunity, or (2) indirectly kills the organism by an opsonin-like reaction, or (3) facilitates a longer drug–parasite contact, is still not clearly understood. Work is in progress to explore the above possibilities.

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Resistance to Colicin *E* as a Genetic Marker in *E. coli* K12

As many genetic markers as possible are needed for the elucidation of possible mechanisms by which bacterial recombination occurs.

A whole group of potential markers is available in the colicins. These are antibiotics produced by some *E. coli* strains, which can inhibit the growth of other strains of the same or closely related species[1]. Unfortunately, none of these substances has been obtained pure, so that they cannot be used as selective agents during the recombination technique but only as unselected markers with which the parent strains and their progeny can be labelled. Several of the colicins produce wide zones of inhibition with sensitive strains and are therefore possible useful markers[2]. In particular, colicin *E* possesses all the requirements of a good marker and its linkage to other known markers can be studied.

The strains of *E. coli* used were the wild-type *K*12 strain which grows on inorganic salt medium with glucose (minimal medium)[3], strain 58.161 requiring methionine (M–) for growth, and strain *W*677 requiring threonine (T–), leucine (L–) and thiamine (B_1–) for growth; both *F*+ and *F*− types of these strains were used. All these strains are sensitive to colicin *E*, and resistant mutants were selected by inoculating approximately 10^9 cells of the parent strain on to nutrient agar plates containing 10 per cent of a 24 hr. broth filtrate of the colicin *E*-producing strain *CA*38. Recombinations were carried out and the progeny tested by the techniques described previously[4]. Colicin *E* sensitivity of the recombinants was tested by the method of Fredericq[5].

The results of four recombination experiments in which the mixture of the washed parent strains was seeded on to different selective media are shown in Table 1. In the first two crosses, in which *W*677 was the *F*− parent, selection for T+, L+ and B_1+ by seeding the mixture on to unsupplemented minimal medium yields a progeny of which 75–82 per cent is resistant to colicin *E*. Addition of thiamine to the selecting medium, which allows B_1-dependent colonies to grow, greatly increases the number of recombinants, and of these only 2–14 per cent are resistant to colicin *E*. There is evidently an association or linkage between the B_1+ and E^R characters of the *F*+ parent. The cross of *W*677 $E^R/F-$ with 58.161/*F*+, in which the *F*− parent carries the marker for colicin *E* resistance, gives results which are in agreement with the localization of the E^R locus close to that of B_1. In this case, when selection is for T+, L+ and B_1+ the locus for colicin *E* sensitivity is present in 50 per cent of the progeny. Removal of selection for B_1+ reduces this to 6 per cent, that is, 94 per cent of the progeny have the E^R locus of the *F*− parent. The cross of $WE^R/F+$ with 58.161/*F*− also yielded concordant results; in this instance, selection for *M*+ carries over 56 per cent of colicin E^R; addition of B_1 to the selecting medium gives a progeny 90 per cent of which is E^R. The loci for M and B_1 in 58.161 are known to be closely linked[6], and the greatly increased transfer of E^R when survival of the B_1− marker of 58.161 is allowed shows that the locus for colicin E^R lies between the loci for M and B_1.

Table 1. Analysis of Recombinants

Cross	Supplements to minimal medium	Recombinants (Nos.)	% B_1	% colicin E^R
58 E^R × *W*/*F*−	None	88	—	75
	B_1	600	55	2
	Lactose	50	—	66
	Lactose B_1	200	52	14
*K*12 E^R × *W*/*F*−	Strep.	500	—	82
	Strep. B_1	800	70	14
	Strep. lactose	400	—	92
	Strep. B_1 lactose	600	96	24
58/*F*+ × *W* E^R/*F*−	None	100	—	50
	B_1	600	?	94
	Lactose	50	—	58
	B_1 lactose	200	?	93
W E^R/*F*+ × 58/*F*−	None	150	—	56
	B_1	175	?	90

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A *Limax*-Amœba from the Rectum of the Grass Snake, *Natrix natrix*, as a Facultative Aerobe *in vitro*

Although small amœbæ of the *limax*-type appear fairly commonly in cultures initiated from standing fæces or the intestinal contents of animals, in only a very few cases has the truly entozoic status of the amœba thus recovered been authenticated. The test hitherto has been the direct observation of the trophic amœbæ in host material, either in fresh

preparations (for example, *Vahlkampfia lacertae* (Hartm.) from the large intestine of *Lacerta muralis*[1] and an unnamed amœba seen by Mackinnon[2] in the intestine of a Tipulid larva) or in fixed and sectioned material (for example, *V. discorbini* Calv.[3], parasitic in the Foraminiferan, *Discorbis mediterranensis*). Nevertheless, the frequent occurrence of *limax*-amœbæ as presumptive anaerobes, or, at least, facultative anaerobes, makes it tempting to suppose that some of them are also facultative parasites. Yet, so far, little experimental investigation of the status of *limax*-amœbæ has been reported. The following is a preliminary account of a strain, called *Am*, of *limax*-amœbæ isolated in this laboratory in June 1953.

A washing from the rectum of a living grass-snake, *Natrix natrix*, was inoculated into Ehs medium[4]; the amœba was detected three days later, isolated from accompanying flagellates, and has lived easily and in good health *in vitro* ever since. The trophic organism is a typical *limax*-amœba, with a single nucleus containing a large karyosome, and ordinarily using a single, broad pseudopodium during movements of translation. Its only remarkable feature is the small size, the mean diameter of two hundred rounded specimens being 5·5μ; the cysts are elliptical, thick-walled and refringent, uninucleate, 5·5μ × 3·5μ (mean of 200). No flagellated phase has yet been detected. The identity of the amœba has yet to be determined: it appears at present to differ from all recorded species in its minute size, and from most in the shape of the cyst.

When grown in upright tubes of medium containing dilute horse serum fortified with 'Marmite'[5] or in Boeck tubes of Ehs medium, the organism can be recovered from the bottom of the liquid (that is, the normal site for parasitic anaerobes such as *Entamoeba* spp.) for three–four days, and then normally disappears; but on the surface of the liquid it flourishes for at least twenty days. On nutrient agar, or non-nutrient agar spread with *Aerobacter*[6], it survives as on the surface of liquid media. Cysts were formed on liquid and solid media. To explore the oxygen requirements further, ten tubes of horse serum with 'Marmite' medium containing fresh sub-cultures of the amœba were set up in pairs in five McIntosh and Fildes anaerobic jars, *A–E*. All were exhausted of air, and *A–D* were filled with hydrogen, *E* with oxygen. Tubes were withdrawn from *A*, *B*, *C* and *D* for examination on the second, third, fifth and twenty-first days respectively; the two tubes in *E* were taken out and examined on each of these days and, on the first three, replaced in oxygen. In every tube, healthy, active trophic amœbæ were found, showing complete tolerance of either atmosphere.

Attempts to infect three clean hosts (*N. natrix*) orally with cysts and trophic amœbæ were unsuccessful. Of attempts to infect two clean hosts rectally with cysts, one was negative and one positive, the infection lasting seventeen days and then dying out. Two attempts to infect hosts rectally with trophic amœbæ were successful, the infections being maintained until the animals died ten and twenty-one days after being inoculated.

When living on the surface of liquid media or on agar, the organism behaves like an ordinary free-living *limax*-amœba; indeed, non-nutrient agar with *Aerobacter* was the medium devised by Singh specifically for small soil amœbæ. In the snake, at the bottom of liquid media, and in hydrogen, the organism behaves like a typically entozoic anaerobe. It is to be regarded as completely facultative in habit and respiratory requirement.

A full account of the experiments will appear elsewhere, together with the results of other work now in progress. I wish to thank Dr. Brendan Moore, of the Public Health Laboratory, Exeter, for allowing me the use of his battery of McIntosh and Fildes jars.

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Dec. 30.

[1] Dobell, C., *Arch. Protistenk.*, **34**, 139 (1914).
[2] Mackinnon, D. L., *Arch. Protistenk.*, **32**, 267 (1914).
[3] Le Calvez, J., *Arch. Zool. exp. et gén.*, **81**, 123 (1940).
[4] Dobell, C., and Laidlaw, P. P., *Parasitol.*, **18**, 283 (1926).
[5] Jones, W. R., *Ann. Trop. Med. Parasit.*, **40**, 130 (1946).
[6] Singh, B. N., *Nature*, **165**, 65 (1950); *Phil. Trans. Roy. Soc.*, B, **236**, 405 (1952).

Use of Liquid Propane as Refrigerant

In discussing the precautions required when liquefying propane for use as a refrigerant for biological specimens, J. L. Stevenson[1] points out, and correctly, the necessity for preventing the simultaneous liquefaction of air. However, this liquefaction does not occur at the boiling point of oxygen, 90° K., as would be inferred from his communication, but only at temperatures below the dew point of air, which is about 82° K.

While at 86° K. a second liquid layer cannot be formed by condensation of air, it is still possible that such a layer might be produced by solution. We have been unable to find any report of data for the system propane/oxygen at 90° K.; but, from the data referring to similar systems, we estimate the solubility of oxygen in liquid propane to be about 2 per cent, which is safely below the explosive limit.

We have made extensive use of liquid propane as the bath liquid for low-temperature cryostats without ill-effects. The liquid is contained in a double-walled vessel immersed in liquid nitrogen, the space between the walls being filled with helium gas. Thus, the interior is at a temperature appreciably higher than that of the liquid-nitrogen bath. In filling, gaseous propane is passed through a cooled spiral in which it condenses, so that liquid at low temperature (about 95° K.) is run into the vessel. Final cooling occurs therein down to temperatures as low as 86° K., at which temperature liquefaction of atmospheric oxygen will not occur. In our opinion, it is undesirable to allow liquefaction to occur in an open vessel where heat exchange is likely to be poor, owing to the large amount of combustible gas liberated.

We would also mention that in our experience hazards can occur when it is necessary to undertake glass-blowing operations on apparatus that has held liquid propane or similar combustible materials. Great care must then be exercised to ensure that all traces of these materials are removed from the apparatus before working on it.

A. H. Cockett

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The British Oxygen Co., Ltd.,
Deer Park Road,
London, S.W.19.
Dec. 29.

[1] Stevenson, J. L., *Nature*, **174**, 235 (1954).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 2

SOCIETY OF ENGINEERS (in the Apartments of the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. C. E. R. Sherrington: "American Railways and Their Modern Technical Developments".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Annual General Meeting, followed by Dr. A. J. E. Welch: "The Inorganic Chemistry of Complex Metal-Oxide Systems".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Sir Miles Clifford: "The Falkland Islands and Their Dependencies".

Tuesday, May 3

WRIGHT-FLEMING INSTITUTE OF MICROBIOLOGY (at St. Mary's Hospital Medical School, London, W.2), at 5 p.m.—Sir Zachary Cope: "Some Peculiarities of the Clinical Pathology of Actinomyces" (Almroth Wright Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. W. V. Mayneord: "Medical Uses of Radioactive Isotopes".

Wednesday, May 4

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Major Oliver Stewart: "New Ways of Flying" (Trueman Wood Lecture).

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Prof. Sir Cyril Burt: "The Meaning and Assessment of Intelligence" (Galton Lecture).*

INSTITUTION OF ELECTRICAL ENGINEERS (joint meeting with the INSTITUTION OF CIVIL ENGINEERS and the INSTITUTION OF MECHANICAL ENGINEERS, at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Sir Harold Hartley, F.R.S.: "The Engineers' Contribution to the Conservation of Natural Resources" (First Graham Clark Lecture).

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

ROYAL AERONAUTICAL SOCIETY, GRADUATES' AND STUDENTS' SECTION (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Mr. E. J. Catchpole and Mr. W. J. Eggington: "Technical Aspects of Supersonic Aircraft Design".

Thursday, May 5

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "Magneto-Hydrodynamics", opened by Sir Edward Bullard, F.R.S.

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Scientific Papers.

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. C. F. A. Pantin, F.R.S.: "Terrestrial Nemertines and Convergent Evolution".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. W. Grey Walter: "The Electrical Activity of the Brain".

UNIVERSITY COLLEGE LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. G. P. Wells, F.R.S.: "The Sources of Animal Behaviour".*

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (in the Large Hall of the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 6 p.m.—Annual General Meeting, 6.15 p.m.—Dr. H. G. Thornton, F.R.S.: "Recent Advances in Soil Microbiology".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

Friday, May 6

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. E. N. da C. Andrade, F.R.S.: "Three Great Natural Philosophers—Gilbert, Hooke, Newton".* (Further lectures on May 9 and 11.)

ROYAL METEOROLOGICAL SOCIETY, MANCHESTER CENTRE (at the University, Manchester), at 6.30 p.m.—Prof. G. Manley: "Climatic Fluctuation—Field Evidence and Mathematical Frolics".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. F. P. Bowden, F.R.S.: "Fast Reactions in Solids and the Birth and Growth of Explosions".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN PHYSICAL CHEMISTRY—Prof. R. M. Barrer, Chemistry Department, Imperial College, London, S.W.7 (May 3).

READER IN GEOLOGY at King's College, Strand, London, W.C.2—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 5).

RESEARCH OFFICER (honours graduate with adequate teaching experience, and preferably with an academic qualification in psychology or education), for work in secondary schools, with special reference to technical education—The Director, National Foundation for Educational Research, 79 Wimpole Street, London, W.1 (May 6).

ASSISTANT LECTURER or LECTURER (preferably with specialist knowledge of systematic botany) IN THE DEPARTMENT OF BOTANY, and an ASSISTANT LECTURER IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Liverpool (May 7).

ASSISTANT LECTURER (with special qualifications in organic chemistry) IN CHEMISTRY—The Registrar, The University, Manchester 13 (May 7).

ASSISTANTS (2) (preferably with an honours degree in bacteriology or equivalent qualification) IN THE DEPARTMENT OF BACTERIOLOGY, to take part in the lecturing and advisory work of the department—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (May 7).

PHARMACOLOGIST (with a first- or second-class honours degree or equivalent qualification in physiology or pharmacology, and preferably familiar with modern methods of separation, identification, and assay of active principles in biological fluids), at a Ministry of Supply Establishment, near Salisbury, Wilts, for experimental work concerned with determining the mode of action of drugs and the assessment of therapeutic measures—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.111/5A (May 7).

SENIOR LECTURER (with high academic qualifications and some research experience, preferably in industry) IN ELECTRONICS—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (May 7).

DEMONSTRATOR (with at least a good honours degree) IN THE PHYSICS DEPARTMENT of University of London King's College, for duties which include devising new experiments, organizing and demonstrating in the practical classes of degree courses—The Registrar, King's College, Strand, London, W.C.2 (May 9).

SENIOR LECTURER IN MATHEMATICS—The Principal, Newland Park Training College, Chalfont St. Giles, Bucks (May 10).

ASSISTANT LECTURER (female) (preferably with special interests in plant ecology and/or plant morphology) IN BOTANY—The Principal, Royal Holloway College, Englefield Green, Surrey (May 14).

LECTURER IN MATHEMATICAL STATISTICS, a LECTURER IN BIOCHEMISTRY, a LECTURER or ASSISTANT LECTURER IN PSYCHOLOGY (with special reference to physiological aspects), an ASSISTANT LECTURER IN PURE MATHEMATICS, and an ASSISTANT LECTURER or RESEARCH ASSISTANT IN VIRUS DISEASES—The Secretary, University College, Exeter (May 14).

LECTURER (with a good honours degree and an interest in the history and philosophy of science) IN EDUCATION—The Registrar, The University, Sheffield (May 14).

ASSISTANT LECTURERS and DEMONSTRATORS IN THE DEPARTMENTS OF BACTERIOLOGY, NUTRITION and PHYSICS—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8 (May 20).

ASSISTANT IN BOTANY—Secretary of University Court, The University, Glasgow (May 21).

ASSISTANT LECTURER (with special interests in the field of cartography) IN GEOGRAPHY—The Registrar, University College, Singleton Park, Swansea (May 21).

LECTURER or ASSISTANT LECTURER (suitably qualified graduate with experience in one or more of the following fields: measurements, D.C. and A.C. machinery, servo-mechanism, high vacuum technique, engineering acoustics, electronic circuit technique or communications) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, The University, Manchester 13 (May 21).

PROFESSOR (with good academic qualifications and practical experience) OF ELECTRONICS, at Madras Institute of Technology—High Commission of India, Establishment Department, Aldwych, London, W.C.2, quoting 4/86D (May 21).

SENIOR ASSISTANT IN RESEARCH within the DEPARTMENT OF ENGINEERING, to work on a project concerning heat transfer in liquid metals—The Secretary of the Appointments Committee, Engineering Laboratory, University of Cambridge, Trumpington Street, Cambridge (May 21).

LECTURER IN MATHEMATICS—The Secretary, The University, Birmingham 15 (May 23).

PLANT BREEDER, Senior Scientific Officer or Principal Scientific Officer grade (with a good honours degree and practical experience)—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (May 23).

TECHNICAL OFFICER (with a degree in science or engineering or equivalent qualifications, and preferably with experience in coal utilization research) IN THE COAL RESEARCH SECTION, Commonwealth Scientific and Industrial Research Organization, North Ryde, New South Wales, to assist in investigations into the combustibility and reactivity of coals and cokes—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 480/165 (May 27).

LECTURER (graduate in metallurgy or chemistry and with special qualifications in spectroscopic or other modern analytical techniques, and preferably with experience in metallography) IN METALLURGY—The Registrar, The University, Manchester (May 31).

ZOOLOGIST, Scientific Officer grade (with general research experience), to do research on quantities of zooplankton in the sea and their fluctuations in relation to the environment—The Secretary, Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, Devon (May 31).

NUFFIELD FELLOW (with suitable postgraduate experience, and detailed knowledge of the structure of at least one foreign European language) IN THE COMPUTATIONAL LABORATORY, for work on problems connected with the use of computing machines for mechanical translation—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (June 15).

CHAIR OF STEAM ENGINEERING AND REFRIGERATION in the Faculty of Engineering, Alexandria University—The Dean, Faculty of Engineering, Alexandria, Egypt (June 20).

PROFESSOR (with a good honours degree and preferably with research experience in plant pathology, systematic botany or genetics) OF BOTANY, a READER (with a good honours degree and research experience in soil physics or soil chemistry) IN SOIL SCIENCE AND

CHEMISTRY, and a LECTURER (with a good honours degree and research experience in the nutrition and management of livestock) IN ANIMAL HUSBANDRY, at the Imperial College of Tropical Agriculture, Trinidad, B.W.I.—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (June 20).

AGRICULTURAL OFFICER (Tobacco) (with a university degree in agriculture, or a related subject, and with a knowledge of field experimentation and practical experience of the cultivation of tobacco, including flue-cured tobacco), in Uganda, to make a survey of tobacco potentialities, and to be in charge of all investigational work on this crop—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.63/9/01.

ASSISTANT EXPERIMENTAL OFFICER (with G.C.E. advanced level in chemistry and one other science subject and bacteriological experience) AT THE FOOD INVESTIGATION ORGANIZATION'S HUMBER LABORATORY, Hull, to assist in research work on various aspects of the bacteriology of fish spoilage, including the hygiene of commercial fish handling—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.16/5A.

CHEMIST (with a good honours degree or equivalent qualification, and preferably with some research experience), to assist with biochemical studies of ruminant digestion with particular reference to the carbohydrate fractions of herbage, silage, hay and other roughages—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting 55/7.

DEMONSTRATOR (preferably with experience of microbiology) IN BIOCHEMISTRY, to teach and carry out research on the biochemistry of micro-organisms—The Administrator, Department of Biochemistry, University of Oxford, South Parks Road, Oxford.

ELECTRICAL ENGINEER, Senior Experimental Officer grade (with at least H.S.C. (science) or equivalent, or preferably with a degree in electrical engineering or corporate membership of the I.E.E.), to lead a small team to guide designers in the choice of electronic components—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting A.301/WGE/34.

FOREST UTILIZATION OFFICER (with a university degree either in forestry or engineering, and with postgraduate experience in forest engineering and/or in timber utilization) in Northern Nigeria, to conduct research into the use of indigenous hardwood timbers by the Rhodesia copper mining industry, with particular attention to fungal decay and preservative treatment of underground mining timbers, to assist sawmilling and logging firms on improved methods of logging, etc., and to assist in the development of wood-using industries—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.61/3/02.

HEAD (with good academic qualifications and industrial experience) OF THE NATIONAL COLLEGE OF HOROLOGY AND INSTRUMENT TECHNOLOGY—The Secretary, National College of Horology and Instrument Technology, Northampton Polytechnic, St. John Street, London, E.C.1.

MASTER TO TEACH APPLIED MATHEMATICS AND PHYSICS to advanced standard level—The Director of Studies, The Nautical College, Pangbourne, Berkshire.

MICROBIOLOGIST, Senior Scientific Officer or Principal Scientific Officer grade (with at least a second-class honours degree in a natural science subject, plus three years or more postgraduate microbiological research experience), in the Research Branch, Colonial Microbiological Research Institute, Trinidad, to supervise and take part in the microbiological work of the Institute under the overall direction of the Director—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.208/209/02.

MYCOLOGIST, Scientific Officer or Senior Scientific Officer grade (with at least a second-class honours degree in botany, and with two years appropriate postgraduate experience and training in plant pathology), at the West African Cacao Research Institute, Gold Coast, to investigate the black pod disease of cacao and its control, and to study the fungi associated with capsid damage, their pathogenicity and control—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.197/200/09.

PHYSICIST or PHYSICAL CHEMIST, Senior Scientific Officer or Scientific Officer grade (with at least a second-class honours degree in physics, chemistry or physical chemistry, and preferably with experience in electron X-ray diffraction), to take part in the work being done in the ELECTRON AND X-RAY DIFFRACTION SECTION of the Metallurgy Division—The Establishments Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/282.

PLANT PATHOLOGIST (with a good honours degree and some experience in research) IN THE DEPARTMENT OF HOP RESEARCH—The Registrar, Wye College, near Ashford, Kent.

PRINCIPAL SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in chemical engineering with experience of research in that field, or in chemistry with postgraduate experience either as a physical chemist in the chemical engineering field, or as a research chemical engineer), to lead a team concerned with developing special equipment from fundamental studies of a physicochemical nature, including hydrodynamical and fluid pumping problems, electrochemistry of solutions, chemical kinetics and phase equilibria—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 561/WGE/2.

SENIOR TECHNICIAN IN HISTOLOGY—The Group Secretary, North Middlesex Hospital, Edmonton, London, N.18.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Coal Tar Research Association. Review of Coal Tar Technology. January–June 1954 (Vol. 6, Part 1). Pp. 108. (Gomersal: Coal Tar Research Association, 1955.) 7*s*. 6*d*. [212

British Museum (Natural History). Economic Series No. 15: Common Insect Pests of Stored Food Products—a Guide to their Identification. By Dr. H. E. Hinton and Dr. A. Steven Corbet. Third edition. Pp. iv+61. (London: British Museum (Natural History), 1955.) 2*s*. 6*d*. [212

University of Leeds. Publications and Titles of Theses, 1950–1. Pp. 53. (Leeds: The University, 1954.) 6*d*. [212

British Iron and Steel Research Association. The Prevention of Corrosion. Pp. 20. (London: British Iron and Steel Research Association, 1955.) 2*s*. [212

Library Association. Books for Young People. Group 2: Eleven to Thirteen plus (Annotated and Classified). Compiled by the North Midland Branch of the Library Association, under the Editorship of Edgar Osborne. New edition, completely revised. Pp. 127. (London: Library Association, 1954.) 7*s*. 6*d*. (6*s*. to members of the Association.) [212

Fire Protection Association. Industrial Solvents and Flammable Liquids: a List giving the Properties Most Useful in Assessing the Fire Hazard. Pp. 20. (London: Fire Protection Association, 1954.) [212

Admiralty Bulletin No. 62: The Production of Fresh Water from Salt or Brackish Water. By J. Leicester. Pp. 13. (London: Admiralty, Chief of Naval Information, 1954.) [212

Aero Research Technical Notes. Bulletin No. 144 (December 1954): Static Tests and Fatigue Tests on "Redux"—Bonded Built-up and Solid Light Alloy Spar Booms. Pp. 16. (Duxford: Aero Research Limited, 1954.) [212

Flexure Devices: Pivots, Movements, Suspensions—a Bibliographical Survey. By P. J. Geary. (A Bibliographical Survey of Instrument Parts—Number 1.) (B.S.I.R.A. Research Report M.18.) Pp. vi+44. (Chislehurst, Kent: British Scientific Instrument Research Association, 1954.) [212

National Smoke Abatement Society. Proceedings of the 21st Annual Conference, Scarborough, 22nd to 24th September, 1954. Pp. 113. (London: National Smoke Abatement Society, 1955.) 7*s*. 6*d*. [212

Bulletin of the British Museum (Natural History). Historical Series. Vol. 1, No. 3: A Catalogue and Historical Account of the Banks Shell Collection. By Guy L. Wilkins. Pp. 69–119+plates 14–19. (London: British Museum (Natural History), 1955.) 20*s*. [212

Liverpool Observatory and Tidal Institute. Annual Report, 1954. Pp. 15+1 plate. (Liverpool: Liverpool Observatory and Tidal Institute, 1955.) [212

British Institute of Management. Management Economic Series No. 2: Control of Stocks for Distribution—the Practice of Ten Companies. Pp. 36. (London: British Institute of Management, 1955.) 5*s*. [212

Admiralty Ship Welding Committee. Structural Trials on S.S. *Ocean Vulcan* and S.S. *Clan Alpine*: Discussion of Results. (Report No. R.12.) Pp. vi+73+8 tables. (London: H.M. Stationery Office, 1954.) 25*s*. net. [212

Tin Research Institute. Some Recent Advances in Tinplate Manufacturing Processes. (An address given at the Congresso Imballaggi, Parma, Italy, September, 1954.) By W. E. Hoare. Pp. 27. (Greenford, Mddx.: Tin Research Institute, 1955.) [212

A Programme for Nuclear Power. (Cmd. 9389.) Pp. ii+22. (London: H.M. Stationery Office, 1955.) 9*d*. net. [212

Statement on Defence, 1955. (Cmd. 9391.) Pp. 30. (London: H.M. Stationery Office, 1955.) 1*s*. net. [212

Bulletins of the Theory of Differential Periodicity. No. 4 (November, 1954). Pp. 24. (Avoca, Co. Wicklow: G. F. Sleggs, 1954.) [212

Royal Institute of Chemistry. Lectures, Monographs and Reports, 1955. No. 1: Ionisation in Organic Chemistry. By Prof. E. D. Hughes. Pp. ii+24. (London: Royal Institute of Chemistry, 1955.) [212

Iron and Steel Institute. Special Report No. 50: Fatigue Tests on Rolled Alloy Steels made on Electric and Open-Hearth Furnaces. By P. H. Frith. Pp. vii+130+22 plates. (London: Iron and Steel Institute, 1954.) 25*s*. (15*s*. to members of the I.S.I.) [212

Other Countries

Indian Council of Medical Research. The Nutrition Research Laboratories, Coonoor, South India. Annual Report for 1953–54. Pp. iii+27. (Coonoor: Nutrition Research Laboratories, 1954.) [212

Forest Research Institute, Dehra Dun. Indian Forest Leaflet No. 137: (Composite Wood)—Studies on Adhesives. Part 17: Adhesives from the Proteins of the Seeds of *Albizzia Lucida*. By D. Narayanamurti and R. K. Jetley. Pp. 5. (Delhi: Manager of Publications.) 4 annas; 5*d*. [212

Scientific Reports of the Indian Agricultural Research Institute for the year ended 30th June, 1953. Pp. 114. (Delhi: Manager of Publications, 1954.) 4 rupees; 6*s*. 6*d*. [212

Indian Forest Records (New Series). Silviculture. Vol. 9, No. 1: An Introduction to the Vegetation of the Assam Valley. By J. B. Rowntree. Pp. iv+87+4 plates. (Delhi: Manager of Publications, 1954.) [212

Publications de l'Observatoire de Genève. Série M, Météorologie. Fascicule 28: Nouvelles moyennes de la température à Genève pour la période 1901–1950. Par Ch. Urfer-Henneberger. Pp. 30. (Genève: Observatoire de Genève, 1954.) [212

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 35, No. 12: Record Population Growth in 1954. Pp. 12. (New York: Metropolitan Life Insurance Company, 1954.) [212

Survey of India. General Report, 1951 (From 1st April 1950 to 31st March 1951). Pp. xi+72+6 Index maps. (Dehra Dun: Geodetic and Training Circle, Survey of India, 1954.) 19 rupees; 30*s*. [212

Bulletin of the Institute for Chemical Research, Kyoto University. Supplementary Issue: The Radioactive Dust from the Nuclear Detonation. Pp. x+133. (Kyoto: Institute for Chemical Research, in collaboration with the Radioisotope Research Committee, Kyoto University, 1954.) [212

U.S. Department of Agriculture. Leaflet No. 379: The Clover Seed Midge: How to Control It. Pp. 5. (Washington, D.C.: Government Printing Office, 1954.) 5 cents. [212

The Hawaiian Chain. By E. H. Bryan, Jr. Pp. iii+71. (Honolulu: Bernice P. Bishop Museum, 1954.) [212